HYDROLOGIC EVALUATION OF THE LAND CONFIGURATION DESIGN BASIS PROJECT SCENARIOS FOR THE ROCKY FLATS ENVIRONMENTAL TECHNOLOGY SITE

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Executive Summary

The Land Configuration Design Basis Project (LCDB) project was initiated to provide the design basis to develop the final Rocky Flats Environmental Technology Site (Site) topography and closure configuration of:

- Streams
- Ponds
- Roads, and
- Other post-closure components

consistent with Site closure, remediation, and final land use objectives. The principal objective for the final land configuration is compliance with the surface-water quality standards identified in the Rocky Flats Clean-up Agreement (RFCA) at the points of evaluation (POEs) and points of compliance (POCs) for the actinides plutonium-239,240 (Pu) and americium-241 (Am). Uranium transport is not addressed in this report. The actinides are associated with soil and sediment particles due to their extremely low solubility. Therefore, mobility of the actinides in overland runoff and streams can be estimated using mathematical erosion and sediment transport models developed by the Site Actinide Migration Evaluation (AME) (KH / RMRS, 2000). An erosion and hydrologic evaluation was conducted, and is reported herein, to quantitatively compare the sediment loading and associated surface-water concentrations of the actinides.

Four bounding LCDB scenarios were modeled to evaluate the broad spectrum of potential Site configuration alternatives summarized in Table Ex-1. The scenarios present different land surface grading and drainage patterns for the Site Industrial Area (IA) and South Interceptor Ditch (SID) watershed. The scenarios also use different hydraulic structures to facilitate settling of sediment-bound actinides in detention ponds, wetlands, and behind energy dissipation structures (e.g. rip rap placed in the stream channels). All of the scenarios use evapotranspiration (ET) covers as reclamation techniques for the Solar Evaporation Ponds, Present Landfill, and Old Landfill.

Table Ex-1. Summary of LCDB Scenarios

Scenario	Industrial Area Configuration	Hydrologic Features	Special Features
0	• Re-vegetated IA • ET Covers on Solar Ponds and Landfills • Re-grade Industrialized Portions of SID drainage	• Existing Drainage Features & Routing	None

Table Ex-1. Summary of LCDB Scenarios - Continued

Scenario	Industrial Area Configuration	Hydrologic Features	Special Features
1	Same as Scenario 0	• Install Engineered Wetlands • Replace Ponds B-1, B-2, B-3, B-4 with Energy Dissipation Structures	• Off-channel wetland in Woman Creek east of Pond C-2 • SID routed to Woman Creek via Pond C-2
2	Same as Scenario 0	• Replace all existing detention ponds with one new pond in Walnut Creek and one new pond in Woman Creek.	• SID routed to Woman Creek through new, expanded Pond C-2
3	• Re-vegetate IA • ET covers on solar ponds and landfills • Realign northern IA tributary to North Walnut Creek.	• Replace all existing detention ponds with armored engineered channels • Eastern SID watershed re-grading	• SID routed directly to Woman Creek • Reduced surface-soil actinide concentrations in eastern SID due to re-grading.

IA = Industrial Area, SID = South Interceptor Ditch, ET = Evapotranspiration

Evaluation of the modeling results provides the following conclusions.

- Re-vegetation and re-direction of overland flow in the IA combined with watershed channel modifications can produce lower actinide yields (i.e. mass movement) and surface-water concentrations than post-remediation (Scenario 0) levels for Walnut Creek and Woman Creek. Therefore, re-vegetation of the IA will likely benefit surface-water quality with respect to actinides.

- Actinide yields and concentrations increase in Scenario 0 for the SID due to increased erodible surface area combined with reduced runoff from the re-vegetated IA. Therefore, IA re-vegetation will reduce SID flow that currently dilutes contaminated sediments.

- Detention ponds are likely the best available control of actinide yields (mass transport), but not necessarily for actinide concentrations (mass per unit volume e.g. pCi/L). Channel scouring downstream from the dams, combined with actinides transported to the stream downstream from the dams (i.e. from erosion and overland flow) will continue to impact surface-water quality.

- Wetlands may be effective controls of actinide yields and concentrations in Walnut Creek, but not necessarily in Woman Creek. This report presents results for a 100-year, 6-hour, 97.1mm (3.82 inches) storm event, which show that contaminated sediments in prototype wetlands could be flushed from the wetlands. Modeling smaller storm events might provide a threshold for wetland effectiveness in controlling actinide transport.

- Installing energy dissipation structures in Walnut Creek is predicted to be effective technique for reducing actinide yields and concentrations.

- Re-grading the eastern SID watershed to reduce the slope of the hillslopes would reduce erosion and the surface soil actinide concentrations. In turn, Woman Creek actinide mass transport (yields) and surface-water concentrations would be reduced.

The results contained herein are for a single, extreme storm event. Therefore, the results cannot be directly compared to RFCA action level compliance at 0.15 pCi/L Pu-239,240 and Am-241, which is based an a 30-day moving average of measured concentrations of flow-weighted composite samples. The model results are accurate to within one order of magnitude for actinide yields and concentrations (KH/RMRS, 2000), and therefore, provide a relative comparison of the Site land configuration bounding scenarios. The estimated peak discharges and runoff yields are not appropriate for structural or civil engineering design purposes.

INTRODUCTION

The Land Configuration Design Basis Project (LCDB) project was initiated to provide the design basis to develop the final Rocky Flats Environmental Technology Site (Site) topography and closure configuration (including drainages, ponds, roads, and other post-closure components) that is consistent with Site closure, remediation, and final land use. The principle objective for the final land configuration is compliance with the surface-water quality standards identified in the Rocky Flats Clean-up Agreement (RFCA) at the points of evaluation (POEs) and points of compliance (POCs) specified in RFCA (Figure 1). An erosion and hydrologic evaluation was conducted, and is reported herein, to quantitatively compare the sediment loading and associated surface-water concentrations of the actinides plutonium-239,240 (Pu) and americium-241 (Am) for each land configuration scenario. Each scenario addresses specific hydrologic impacts on meeting surface-water-quality requirements for the Site at regulatory closure.

The actinides are associated with particulates due to their extremely low solubility (KH/RMRS, 2000). Therefore, mobility of the actinides in overland runoff and streams can be estimated using mathematical erosion and sediment transport models. Between FY98 and FY00, the Actinide Migration Evaluation (AME) erosion and sediment transport models were built and calibrated to provide engineering estimates of actinide mobility due to overland flow, erosion, and sediment transport in streams for existing conditions (KH / RMRS, 2000). The models predict where actinide-contaminated sediments are introduced to streams from overland runoff and erosion, deposited from the water column to the streambed, and/or re-suspended from the streambed to the water-column.

This hydrologic evaluation uses the knowledge, methods, and software developed by the AME erosion and sediment-transport modeling project to evaluate the four bounding LCDB scenarios., which are summarized in Table 1 and described below.

- **Scenario 0** is a baseline scenario, which incorporates a re-vegetated Industrial Area (IA) and changes to the surrounding Buffer Zone (BZ) that are consistent with the anticipated conditions at completion of active remediation, including evapotranspiration (ET) covers for the original landfill, present landfill, and solar ponds. No re-contouring of the land surface other than the ET covers was included in Scenario 0. The existing routing of surface-water runoff is maintained in Scenario 0.

- **Scenario 1** utilizes passive flow-through ponds, energy dispersion structures, and natural wetland treatment systems to detain runoff and allow gravity settling of contaminated sediments, to improve water-quality . Runoff is routed through the existing terminal ponds and existing, modified, or constructed wetlands within North and South Walnut Creeks, and Woman Creek, . The SID is routed to Woman Creek prior to Pond C-2 with the combined flow routed through Pond C-2 and excess flow to the off-channel wetlands.

- **Scenario 2** adds two detention basins in the Site watersheds. One detention basin was placed just upstream from the confluence of McKay Ditch and Walnut Creek to retain flow from North Walnut Creek, South Walnut Creek, No Name Gulch, and overflow from the McKay Diversion. The other detention basin was placed in the Woman Creek channel, incorporating Pond C-2, and is designed to retain the combined flow of the SID and Woman Creek. The detention basins are located and designed to retain the runoff, entrained sediment, and contaminants associated with the sediment. Both detention basins have the capacity to store the combined volume of pre-event runoff and a 6-hour, 100-year runoff event. The pre-event detention volume is defined as the maximum runoff that occurred from 1993 to 1998 over a 30-day period.

- **Scenario 3** is based on source isolation. This scenario utilizes engineered drainages, slope reduction and re-vegetation to reduce erosion of contaminated surface soils to surface water. Drainage controls in the IA and slope reduction erosion control measures are applied to specific sectors that are susceptible to migration and have the potential to cause an exceedance of the surface-water quality standards. These areas include the IA and the B881 / 903 Pad hillslope. Surface water controls for sediment removal (such as settling ponds) are not used in this scenario. The SID is routed directly to Woman Creek in this scenario.

The AME calibrated the Water Erosion Prediction Project (WEPP) model to predict overland flow and erosion for Site hillslopes, and the WEPP-estimated sediment and runoff yields are routed through Site streams using the Sedimentation in Stream Networks (HEC-6T) model (Flanagan et al, 1995, Thomas, 1999). Figure 2 illustrates the AME modeling process (KH/RMRS, 2000). WEPP input files provided by the AME erosion models were modified by the LCDB project to be representative of the conditions associated with each scenario.

The WEPP input files and output results for a 6-hour, 100-year precipitation event for each of the four scenarios were provided to the AME project for evaluation and quality control. The WEPP runoff and sediment yields for each scenario were converted to input for the HEC-6T sediment transport models, which is used to route the runoff and sediment through the Site streams and detention ponds to estimate sediment concentrations and yields. for Walnut Creek, Woman Creek, and the SID. The MS Excel™ –based actinide transport models (ATMs), developed by the AME, were modified for each scenario, and the results of the HEC-6T modeling were entered into the ATMs. The ATMs predict actinide surface-water concentrations from the combined WEPP and HEC-6T modeling output. The ATM results are used to evaluate the bounding scenarios for surface-water quality compliance.

This hydrologic evaluation compares the four scenarios developed by the LCDB. This report contains erosion maps, actinide mobility maps, and average actinide concentrations and loads at selected surface-water Points of Evaluation (POEs) and Points of Compliance (POCs).

WEPP Model Evaluation

All WEPP modeling input and output files were reviewed and evaluated for consistency with the AME models to ensure that differences in results are from differences in land configuration features, not arbitrary differences in modeling parameterization. Each scenario was reviewed and comments were provided as the LCDB Project proceeded. Portions of Scenario 0 were reviewed in June and July, 2001. Scenarios 1, 2, and 3 were reviewed in August, 2001. A comment resolution teleconference was held on August 28, 2001. These documents and the meeting minutes are provided in Appendix A.

The final modeling package was delivered to the AME by the LCDB project personnel for review on October 24, 2001 (RFETS, 2001). The WEPP input and output files were reviewed and a few minor corrections were applied. The WEPP output was then prepared for input to the HEC-6T models for each scenario.

The original calibration of the WEPP model for Site conditions was maintained throughout the LCDB modeling process. Selected WEPP hillslope dimensions were changed, and new hillslopes were created for the IA and the Present Landfill.

HEC-6T Model Development

New HEC-6T models were developed for the four LCDB bounding scenarios. Characteristics of the new HEC-6T models for each scenario are described below.

Scenario 0

Scenario 0 incorporated a re-vegetated IA and changes to the BZ related to covers for the original landfill in the SID drainage and the present landfill in the Walnut Creek drainage. The main change to the HEC-6T model for this scenario was the inclusion of the WEPP-estimated runoff and erosion output for the IA at the upstream end of the model. Previously, surface-water-monitoring data had been extrapolated and input to the upstream end of the HEC-6T models.

The Scenario 0 model includes all existing detention ponds except for the Landfill Pond. The Present Landfill is modeled with an ET cover, which drains directly to No Name Gulch. The SID is routed to Pond C-2 in this scenario.

Scenario 1

In Scenario 1, the non-terminal B-series ponds are re replaced with energy dispersion structures in engineered channels. Terminal ponds, A-4 and B-5, and the C-Series ponds are converted to passive flow-through systems. A wetland was added to the model between Pond A-3 and Pond A-4 on North Walnut Creek. A new wetland was also added below Pond B-5 on South Walnut Creek; extending downstream into Walnut Creek below the confluence of North Walnut Creek and South Walnut Creek. In Walnut Creek, the runoff coefficient for

the T-130 trailer complex was reduced from 0.7, in the model for existing conditions to 0.1 to account for re-vegetation of the drainage area.

Pond C-1 remains in place and the SID is routed to Woman Creek in the Scenario 1 model. Two wetlands were added to Woman Creek near pond C-2; one immediately upstream from the confluence with the SID, and another off-channel wetland, located just east of Pond C-2. In the Scenario 1 model, up to 0.7 m^3/sec (25cfs) is routed through Pond C-2, and flow

exceeding 0.7 m3/sec is diverted to the off-channel wetland. The flow from the off-channel wetland and Pond C-2 outlet are recombined and routed into the Woman Creek main channel. The wetlands are modeled as wide channels filled with vegetation. However, the wetlands have an approximate 2% slope, which is considered steep.

Scenario 2

Scenario 2 adds two detention basins, created by new dams, to Site watersheds. One dam was placed on Woman Creek near the headgate of the Mower Ditch and dovetails with the existing Pond C-2 dam to create an extended Pond C-2 On Walnut Creek, a dam was placed below the confluence of North Walnut Creek, South Walnut Creek, and No Name Gulch. The detention basins are designed to hold all runoff from a 100-year 6-hour event. The original HEC-6T models for Walnut Creek and Woman Creek were truncated at the location of the dams, and only runoff and sediment flowing into the channels below the dams were routed in these models. Baseflow from the dams was held constant at 0.01 m^3/sec (0.5 cfs). Sediment concentrations and suspended sediment activities associated with the baseflow were estimated from Site monitoring data for gaging stations GS11 (Pond A-4 outlet), GS08 (Pond B-5 outlet), and GS31 (Pond C-2 outlet) for the dam discharges.

Scenario 3

Scenario 3 includes engineered drainage channels, slope reduction and re-vegetation to reduce erosion of contaminated surface soils to surface water. The areas modified include the IA, the 903 Pad, and 903 Lip area hillslopes. Surface-water controls for sediment removal (such as settling ponds) are not included in this scenario. The northern IA tributary to North Walnut Creek is modified to capture more runoff from the west by realigning the channel to the east. This modification to the surface hydrology puts more runoff from the IA into North Walnut Creek.

In Scenario 3, the eastern half of the SID watershed is re-graded to reduce the slope of the land surface and reduce runoff and erosion. During re-grading the actinide surface contamination is mixed with the cleaner, underlying soil to an assumed depth of 30 cm, thereby reducing the surface soil actinide concentration in the SID watershed. The SID is routed directly to Woman Creek in Scenario 3.

Preparation of WEPP Output for the New HEC-6T Models

The WEPP output data were converted to HEC-6T input to route the runoff and sediment through the Site drainage channels. The WEPP runoff, peak discharge, storm intensity distribution, and sediment yields from the WEPP output were formatted for HEC-6T using a triangular unit hydrograph method (KH/RMRS, 2000). WEPP hillslopes are treated as tributary inflows to the streams, which are routed together in a network. HEC-6T computes the stream power in the channels using Yang's Equation, which determines the sediment transport capacity of the stream flow (Thomas, 2001). The model computes the quantities of sand, silt, and clay (distributed among nine particle sizes) that are transported and/or

deposited in the stream channel network. Chromec et al (2001), describe the process of integrating WEPP and HEC-6T.

The LCDB Project Team consultant (Parsons) provided WEPP output data and GIS data for the WEPP hillslopes, new drainage channels, and wetlands. The KH AME modeling group (Wright Water Engineers, Inc., Destiny Resources, Inc., and Dyncorp) formatted the data for HEC-6T, ran the HEC-6T models, mapped the data, and estimated surface-water actinide concentrations. The WEPP input and output data files, HEC-6T input and output files, and the Actinide Transport Model (ATM) spreadsheets are contained in Appendix C (CD-ROM in pocket) so that the work may be checked, reproduced, or modified for other scenarios if necessary.

Actinide Transport Models

The sediment and flow data are combined with the estimated quantities of actinides delivered to the streams in the ATM spreadsheets, which are programmed in MS Excel™ (KH / RMRS, 2000). The HEC-6T output file (i.e. files with .t6 file name extensions) contains sediment and runoff yields for the Site streams. The WEPP erosion data and soil actinide data are mapped in grid form in ArcInfo™ (GIS), and a GIS program is run to compute the quantity of actinides delivered to the streams from each hillslope based on the grid values. The particle-size distributions of the actinides on the sediment particles are also included in the ATM spreadsheets. Event-mean actinide concentrations and total actinide yields are estimated and graphed in the ATM spreadsheets. The ATMs are included in Appendix C.

Industrial Area Yields for Existing Conditions

Industrial Area runoff, sediment yields, and actinide concentrations for existing conditions were derived using Site monitoring data for gaging stations GS10, SW093, GS21, GS22, GS24, and GS25. The average total suspended solids concentration measured at each station was multiplied by the event precipitation depth and measured runoff coefficient for each

Gaging station to create sediment discharge rates for design storms (e.g. 100-year, 6-hour (97.1mm) storm).

Triangular unit hydrographs for each IA sub-basin were computed using the storm depth (e.g. 97.1mm), storm duration (e.g. 6 hours), and the average runoff coefficient estimated from measured data. The peak discharge of each IA sub-basin runoff hydrograph is located at one-sixth of the storm duration (e.g. 1 hour), which is consistent with hydrographs provided in the Rocky Flats Plant Drainage and Flood Control Master Plan (EG&G, 1992). Actinide concentrations measured in surface water samples at each IA gaging station were divided by corresponding TSS values to obtain the actinide content of the suspended solids in pCi/g. The average actinide content of the suspended solids was computed for each IA gaging station.

LCDB Scenario Conditions

New ATM models were produced for each scenario. In Scenario 0, changes were made to the ATM to incorporate a re-vegetated IA, landfill covers and direct routing to Woman Creek. For Scenario 1 changes to the ATMs were made to account for the removal of the non-terminal B-series ponds, addition of wetlands in Walnut Creek and Woman Creek, and re-routing of the SID to Woman Creek. In Scenario 2, the ATM models were truncated at the detention ponds in the Walnut Creek and Woman Creek Watersheds. Estimation of actinide yields and concentrations are not computed upstream of the hypothetical dams in Scenario 2.

All ponds were removed from the watersheds for Scenario 3. The slope and soil actinide concentration data for the SID were also reduced to simulate soil grading. Re-grading the eastern SID will also result in a reduced surface soil actinide concentration, which is discussed later herein.

In Scenarios 0, 1, and 3, the WEPP model was used to estimate IA runoff and sediment yields to the streams. The kriged surface-soil actinide concentration grids were used to estimate the actinide content of the delivered sediments using GIS techniques. The modeling data are used in place of the IA gaging station measurements for re-vegetated conditions represented in Scenarios 0, 1, and 3.

In Scenario 2, the average measured actinide concentrations for gaging stations GS08 and GS11 are used for the baseflow discharged from the new hypothetical dam in Walnut Creek. Similarly, average actinide concentrations measured at gaging station GS31 are used for baseflow discharged from the hypothetical expanded Pond C-2 dam in Scenario 2 for Woman Creek. Baseflow from the hypothetical dams is set to 0.03 m^3/sec (1 cfs) at steady state.

Modeling Results for the LCDB Scenarios

Erosion and Actinide Mobility

The erosion maps in Figures 3 and 4 show the results of the WEPP modeling for LCDB Scenarios 1 and 3. On the erosion maps, the warm colors indicate areas with high erosion, and cool colors indicate areas with deposition. Gray areas indicate where data were not obtained from the WEPP model. The boundaries of the erosion models are shown in red.

Figure 3 shows the WEPP erosion modeling results for Scenario 1, which are similar to results for Scenarios 0 and 2. Figure 3 shows the locations of the wetlands near Pond A-4 in Walnut Creek and near Pond C-2 in Woman Creek. The wetland erosion is estimated by HEC-6T, not WEPP. Therefore erosion estimates for the wetlands are not mapped in Figure 3.

Figure 4 shows the WEPP erosion modeling results for Scenario 3. The hillslopes in the IA and up-gradient of the SID are different from Scenarios 0, 1, and 2. The IA drainage pattern in Scenario 3 directs more runoff to the northern portion of the IA, which drains to North Walnut Creek. Diversion of the surface-runoff to North Walnut Creek slightly increases erosion in the northern IA and decreases erosion in South Walnut Creek sub-basin in the IA. Figure 5 compares the erosion and associated actinide mobility for Scenarios 1 and 3.

Figure 5 shows that there is more erosion in the eastern SID watershed in Scenario 1 than in Scenario 3. This is due to the fact that the eastern SID watershed is re-graded to reduce erosion in Scenario 3. Figure 5 shows that there is lower predicted actinide mobility for Scenario 3 than for Scenario 1 in the SID watershed. The reduced actinide mobility and surface-water concentrations are due to reduced slope of the eastern SID watershed hillslopes (i.e. less erosion) combined with reduction of surface-soil actinide concentrations from re-grading and tilling of the surface-soil.

The effects of re-grading the surface soil in the eastern SID watershed are illustrated in Figure 6. Data collected by Dr. M. Iggy Litaor and others, indicates that the actinide concentrations decrease with soil depth (Litaor et al, 1994 and DOE, 1995). If this soil was tilled, the actinide concentration would become more evenly distributed with depth by dilution of the surface concentrations with the deeper, cleaner soil. Therefore, sediment yields to streams from soil erosion would have lower actinide content, which would lower surface-water concentrations. The modeling results are consistent with this logic.

For this analysis, the average surface soil Pu-239,240 and Am-241 concentrations were calculated for each of four sectors (A, B, C, and D) using GIS. The measured vertical distribution of actinides in the soil was used to estimate what the surface concentration would be if the top 30cm of soil was homogenized by grading. The Pu-239,240 and Am-241 soil concentration grids were edited in GIS such that the surface concentration in each sector is a homogeneous mixture of the top 30cm of soil. Figure 7 illustrates the resulting modified surface soil actinide grids used to estimate actinide yield to the SID in Scenario 3.

The independent effects of reducing the slope of the eastern SID hillslopes and surface-soil actinide concentrations were evaluated. Figure 8 shows the results of this evaluation. Predicted concentrations for Pu-239,240 and Am-241 are given for two different modeling conditions: 1) no predicted channel erosion (i.e. no streambed scour) and 2) including predicted channel erosion (i.e. streambed sediment scour and re-suspension). The actual concentrations are expected to be within the range of the values for the two channel erosion conditions. The results shown in Figure 8 indicate that surface-soil actinide concentration reduction by re-grading the eastern SID watershed will reduce surface-water concentrations in Woman Creek by about 30 percent. The slope reduction alone has a negligible effect on actinide concentrations. This is explained by the fact that the slope reduction not only reduces erosion, but runoff as well; producing no net change in actinide concentration.

Surface-Water Actinide Transport

Sediment and associated actinide yields are given for each of the channel erosion conditions. The yields are sum quantities of sediment (in kg) or actinides (in pCi) transported in the surface water to a given point in the watershed. For this report, the sediment and actinide yields are computed for the outlets of each watershed: Walnut Creek at Indiana Street (a.k.a. POC station GS03), Woman Creek at Indiana Street (a.k.a. POC station GS01), and POE gaging station SW027 at the mouth of the SID. Sediment yields and actinide concentrations and yields are also presented for POE stations SW093 and GS10 on North Walnut Creek and South Walnut Creek, respectively, and for POC station GS08 on South Walnut Creek below Pond B-5.

Currently, the Site is regulated by the RFCA requirement that surface-water concentrations of Pu-239,240 and Am-241 be less than 0.15 (picocuries per liter (pCi/L)), based on a 30-day moving average. The analysis presented herein is for a single 100-year, 6-hour, 97.1mm storm event, not a 30-day moving average of continuous-flow-composite samples. Each of the bounding scenarios is evaluated based on the predicted, event-mean actinide concentrations in the flow (in pCi/L) and the total actinide yields (in pCi). The predicted actinide concentrations and yields in surface water are presented for each scenario in Table 2 and in Figures 9, 10, 11, and 12.

The predicted actinide concentrations shown in Figures 9 through 12 indicate how concentrations vary along the reach of a stream channel from upstream to downstream. Once again, predicted concentrations for Pu-239,240 and Am-241 are given for two different modeling conditions: 1) no predicted channel erosion (i.e. no streambed scour) and 2) including predicted channel erosion (i.e. streambed sediment scour and re-suspension), with actual concentrations expected to be within the range of the values for the two models.

In Table 2, comparison of modeling results for Scenario 0 and existing conditions for Walnut Creek and the SID shows that sediment and actinide yields may decrease after IA re-vegetation (Scenario 0). However, runoff is also greatly reduced in Scenario 0. Therefore, concentrations of actinides are predicted to increase in the streams due to decreased runoff and dilution in Scenario 0.

Walnut Creek

Results for Walnut Creek modeling in Table 2 and Figures 9 and 10 show that all bounding scenarios (1, 2, and 3) produce lower actinide yields and concentrations than the baseline configuration (Scenario 0). In Scenario 0, actinide yields at Walnut Creek at Indiana Street (GS03) are reduced by more than a factor of two in both Scenario 1 (wetlands and energy dispersion structures) and Scenario 3 (IA drainage modifications and SID slope-reduction). The Scenario 1 and 3 actinide concentrations at GS03 are nearly a factor of four lower than the Scenario 0 concentrations.

The Walnut Creek wetland channels, installed in Scenario 1, are predicted to have a beneficial effect on actinide yields and concentrations. Comparison of the Scenario 0 and Scenario 1 actinide yields, in Table 2, shows that the wetlands decrease actinide yields by 94 percent at GS03. Typically, and a flood like the 100-year event would be expected to flush sediment and associated constituents from the wetlands, which is the result obtained for Woman Creek. However, for Walnut Creek, the wetlands are predicted to be effective for controlling actinide yields.

The energy dissipation structures in South Walnut Creek are also predicted to be effective at reducing sediment and associated actinide yields for the 100-year event. Comparison of the Scenario 0 and Scenario 1 actinide yields in Table 2 shows that the predicted yields at GS08 are reduced by 70 percent by installation of the energy dissipation structures located between GS10 and GS08 (Figures 9 and 10).

In Scenario 2 (detention basins), predicted actinide yields at GS03 are about a factor of 30 lower than in Scenario 0. Walnut Creek Scenario 2 produces the lowest actinide yield and concentrations; indicating the effectiveness of detention ponds on actinide yields and concentrations (Figure 9).

Predicted actinide yields at GS03 for Scenario 3 are slightly lower than Scenario 1 yields. Predicted actinide concentrations are similar for Scenarios 1 and 3. Replacement of the ponds with non-erodible, engineered channels causes less actinide re-suspension and transport (Figure 9).

South Interceptor Ditch

Modeling results for the SID in Figure 11 show actinide concentrations and yields at gaging station SW027 for existing conditions and Scenario 0. Scenario 0 concentrations are nearly double those for existing conditions for the 100-year event. This is due to an increase in erodible surface area in the SID drainage in Scenario 0 combined with reduced runoff entering the SID.

Woman Creek

Results for the Woman Creek scenario modeling indicate that none of the LCDB scenarios control surface-water actinide concentrations better than either the existing or Scenario 0 configurations (Figure 12). Scenario 0 is similar to existing conditions for Woman Creek because the IA runoff to the SID is captured by Pond C-2 and not routed into Woman Creek in Scenario 0. Routing the SID into Woman Creek in Scenarios 1 and 3 cause actinide yields and concentrations in Woman Creek to increase due to introduction of runoff from the 903 Pad area, which contains soil with the highest actinide concentrations at the Site. Table 2 shows that routing the SID into Woman Creek in Scenarios 1 and 3 causes actinide yields at Indiana Street (GS01) to increase by two- to five-fold compared to Scenario 0.

Scenario 1 and 3 models for Woman Creek assume that Pond C-2 can contain the 100-year event without spilling to Woman Creek. There is a potential for Pond C-2 to spill runoff over the emergency spillway to Woman Creek in the 100-year event, but for this study it was assumed that Pond C-2 contains the 100-year event.

Installation of wetlands in the Woman Creek channel and in the Woman Creek Bypass Canal is not predicted to affect actinide yields and concentrations. The slope of these wetlands is about two percent, which is steep for a wetland area. Furthermore, wetlands would be expected to be flushed from a large flood like the 100-year event (Dr. Katherine Walton-Day, U.S. Geological Survey, Water Resources Division, personal and written communications). Therefore, the results for Woman Creek Scenario 1 modeling are consistent with prototype wetlands. Modeling a smaller storm events for Scenario 1 might provide a flow threshold for wetland effectiveness in controlling actinide yields and concentrations.

Predicted Woman Creek actinide yields for Scenario 2 (new, expanded Pond C-2 dam) are 50 percent lower than the Scenario 0 yields, but there is a slight increase in actinide surface-water concentration for Scenario 2. This is because the detention pond holds most of the stormwater runoff, which reduces the total yield, but also makes the Woman Creek flow more concentrated with actinide activity by reducing the flow. Table 1 shows that Woman Creek Scenario 2 runoff yield is about one-third of the predicted runoff yields for Scenarios 1 and 3. These results are similar to the results obtained for Walnut Creek Scenario 2, which indicate that detention ponds are likely the most effective way to control actinide transport in streams at the Site.

Conclusions

- The modeling results indicate that re-vegetation and re-direction of overland flow in the IA combined with watershed channel modifications can produce lower actinide yields and concentrations than post-remediation (Scenario 0) levels for Walnut Creek and Woman Creek. The converse was true for the SID. In the SID, an increase in erodible surface area combined with a loss of runoff from the IA resulted in less dilution of the actinides and thus higher post-remediation surface-water concentrations.

- Modeling results indicate that detention ponds are likely the best available control of actinide yields, but not necessarily for actinide concentrations. The modeling indicates that continued channel erosion combined with actinides transported from overland flow downstream from the dams, combined with reduced / attenuated flows, will increase actinide concentrations in the streams below the dams.

- Modeling results indicate that wetlands and/or energy dissipation structures in Walnut Creek are effective controls of actinide yields. However, modeling of wetland controls in Woman Creek indicated that they had little effect on actinide yields and concentrations for the 100-year, 6-hour storm event. This large event, consisting of 97.1mm of precipitation in six hours, would be expected to flush prototype wetlands. Therefore, the modeling results for Woman Creek are consistent with natural wetland processes. Modeling smaller storm events might provide a threshold for wetland effectiveness in controlling actinide transport.

- Comparison of modeling results for Scenarios 1 and 3 in Woman Creek indicate that re-grading the eastern SID watershed to reduce the slope of the hillslopes would reduce erosion and actinide mobility. In addition, tilling the soil will lower the surface-soil actinide concentrations. Consequently, the predicted Woman Creek actinide yields and concentrations are reduced, as shown in Scenario 3. The Scenario 3 models for Woman Creek demonstrate that re-grading the contaminated soil is an effective technique for controlling actinide transport at the Site.

- The results contained herein are for a single, extreme storm event. Therefore, the results cannot be directly compared to RFCA action level compliance at 0.15 pCi/L Pu-239,240 and Am-241, which is based an a 30-day moving average of measured, composite sample concentrations. Modeling smaller storm events and extrapolation of those model results to continuous climate record could provide an evaluation of RFCA compliance based on 30-day moving average concentrations.

- The modeling results provide a relative comparison of the Site land configuration bounding scenarios. The accuracy of the results is believed to be within one order of magnitude for actinide yields and concentrations (KH/RMRS (2000)). The estimated peak discharges and runoff yields are not appropriate for structural or civil engineering design purposes, but the hydrology and channel hydraulics predicted by the models are realistic and reasonable. Culvert sizing, bridge design, and other design engineering should rely on standardized engineering techniques, not the flows predicted by these models.

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FIGURES

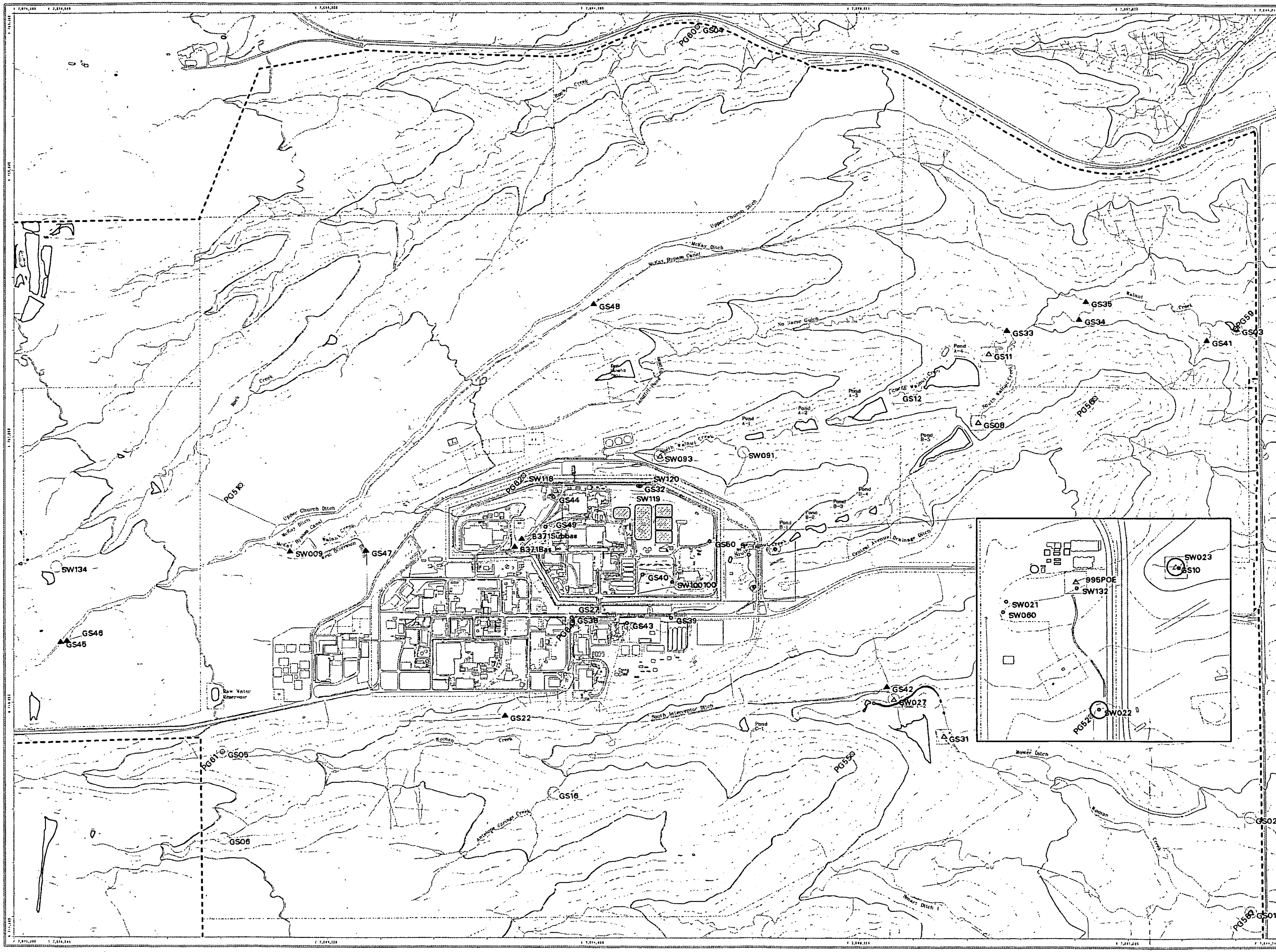


Figure 1

Automated Surface Water Monitoring Locations and Precipitation Gages for FY 2001

EXPLANATION

- Precipitation Gage

Monitoring Location Objective*

- Buffer Zone Hydrologic
- New Source Detection
- Point of Compliance
- Point of Evaluation
- Source Location
- Ad Hoc
- Performance
- IDLH**

Standard Map Features

- Buildings and other structures
- Solar Evaporation Ponds (SEP)
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Contour (20-Foot)
- Rocky Flats boundary
- Paved roads

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95
Topology (contours) were derived from digital elevation model (DEM) data by Morrison Knudson (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~10 meter resolution. DEM post-processing performed by MK, Winter 1997.

NOTE:
* The monitoring objective(s) performed at each location are detailed in the Surface Water Section of the Site Integrated Monitoring Plan.

** IDLH (Immediate Danger to Life & Health) refers to the monitoring objective for safe operation of the Site detention ponds.

Scale = 1 : 17870
1 inch represents approximately 1489 feet

250 0 500 1000ft

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

GIS Dept. 303-966-7707

Prepared by: DynCorp THE ART OF TECHNOLOGY

Prepared for: KAISER-HILL COMPANY

MAP ID: 2k-0227

October 31, 2000

Original map contents are preserved. Logo and date have changed.

Figure 2. Schematic Diagram of the AME Erosion, Sediment, and Actinide Transport Modeling Process

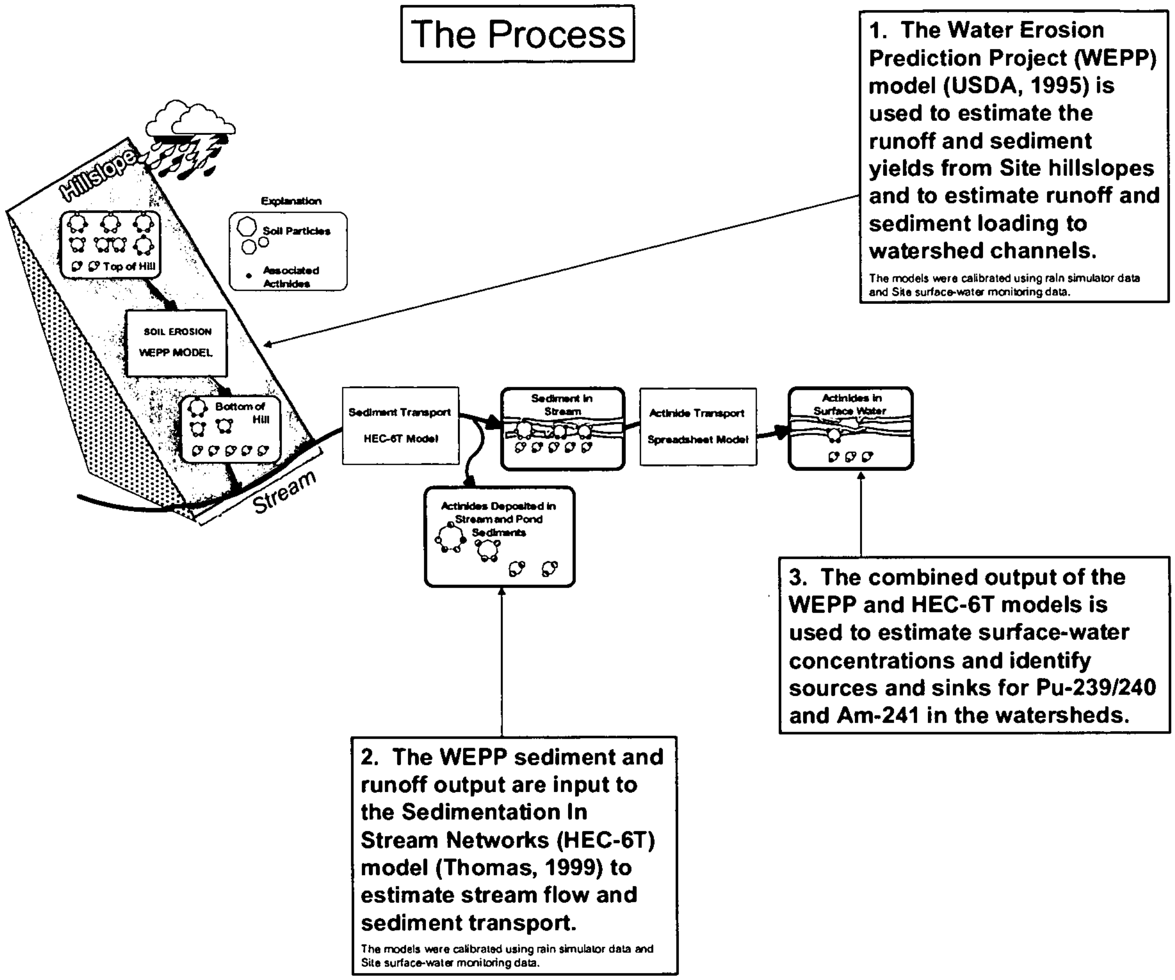


Figure 3
LCDB Scenarios 0, 1 and 2
Erosion
100-Year Event (97.1mm)

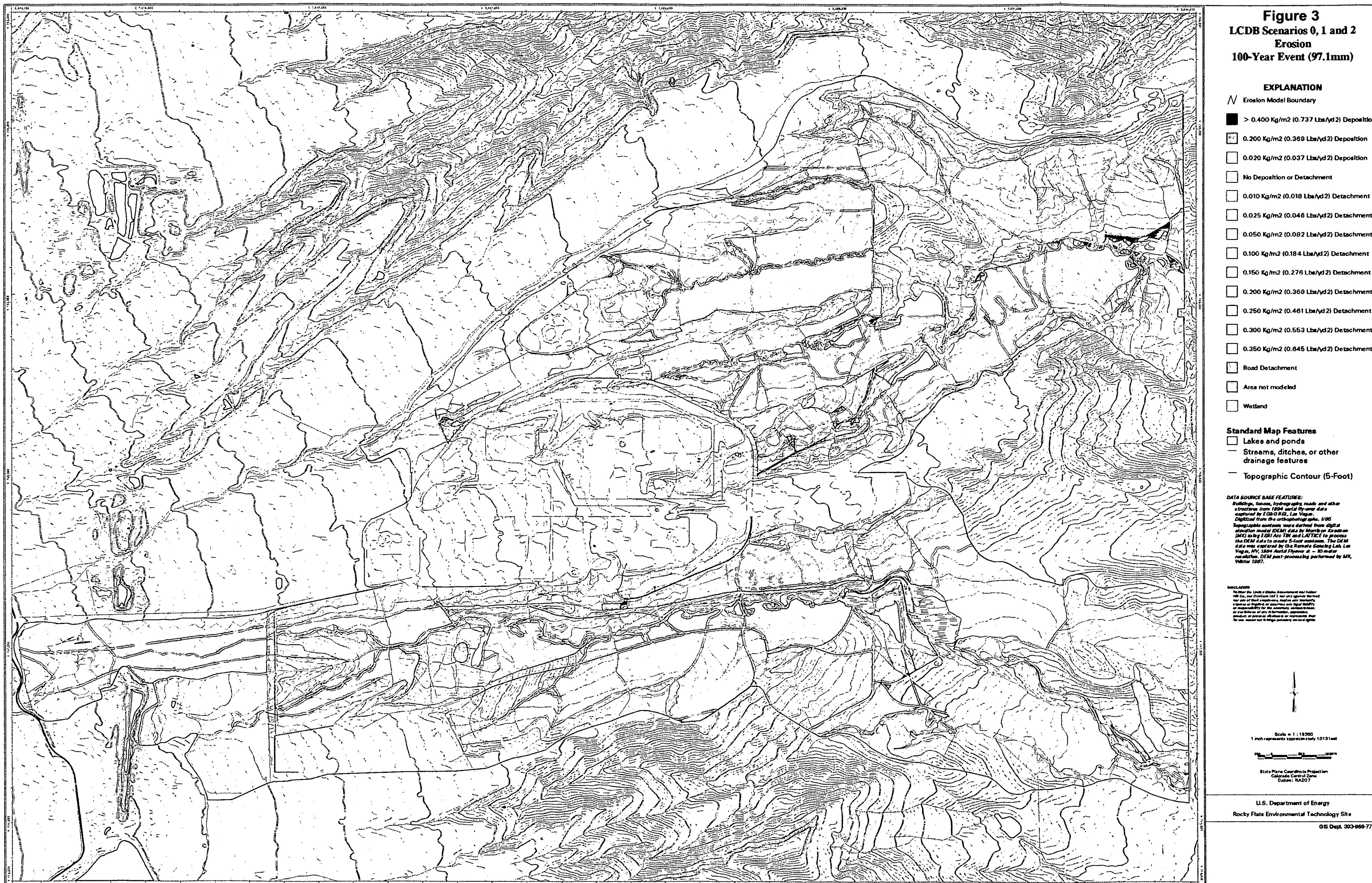


Figure 4
LCDB Scenario 3
Erosion
100-Year Event (97.1mm)

EXPLANATION

- Erosion Model Boundary
- > 0.400 Kg/m2 (0.737 Lbs/yd2) Deposition
- 0.200 Kg/m2 (0.369 Lbs/yd2) Deposition
- 0.020 Kg/m2 (0.037 Lbs/yd2) Deposition
- No Deposition or Detachment
- 0.010 Kg/m2 (0.018 Lbs/yd2) Detachment
- 0.025 Kg/m2 (0.046 Lbs/yd2) Detachment
- 0.050 Kg/m2 (0.092 Lbs/yd2) Detachment
- 0.100 Kg/m2 (0.184 Lbs/yd2) Detachment
- 0.150 Kg/m2 (0.276 Lbs/yd2) Detachment
- 0.200 Kg/m2 (0.369 Lbs/yd2) Detachment
- 0.250 Kg/m2 (0.461 Lbs/yd2) Detachment
- 0.300 Kg/m2 (0.553 Lbs/yd2) Detachment
- 0.350 Kg/m2 (0.645 Lbs/yd2) Detachment
- Road Detachment
- Area not modeled
- Wetland

Standard Map Features

- Lakes and ponds
- Streams, ditches, or other drainage features
- Topographic Contour (5-Foot)

DATA SOURCE BASE FEATURES:
Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95
Topographic contours were derived from digital elevation model (DEM) data by Morrison Knudsen (MK) using ESRI Arc TIN and LATTICE to process the DEM data to create 5-foot contours. The DEM data was captured by the Remote Sensing Lab, Las Vegas, NV, 1994 Aerial Flyover at ~ 10 meter resolution. DEM post-processing performed by MK, Winter 1997.

Scale = 1 : 19360
1 inch represents approximately 1613 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

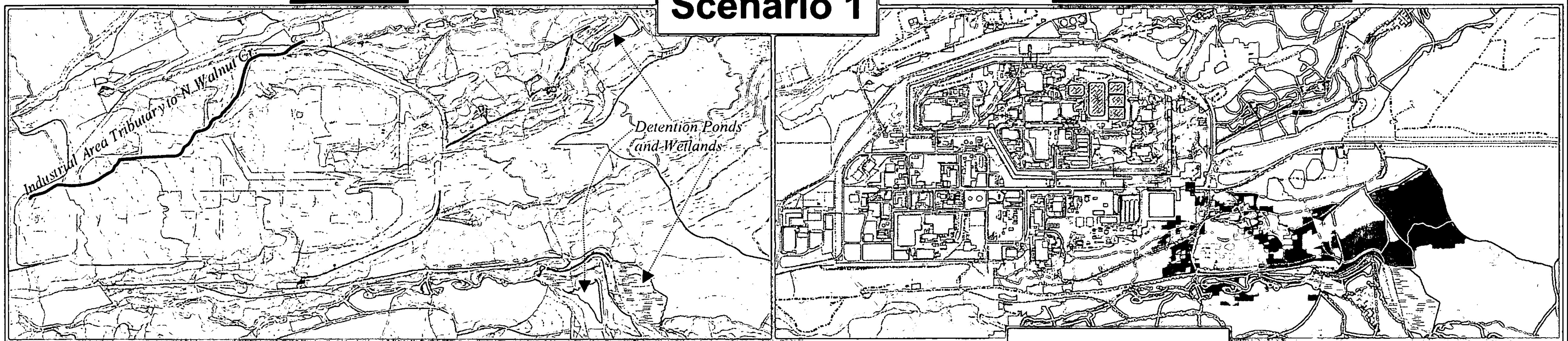
GIS Dept. 303-966-7707

MAP ID: 02-0159/all_erosion_scn3.aml
December 28, 2001

NT Svr d:/projects/fy2002/02-0159/all erosion scn3.aml

Figure 5.
Comparison of Estimated Erosion and Pu-239,240 Mobility Grids for LCDB Scenarios 1 and 3 - 100-Year, 6-Hour Storm (97.1mm)

Erosion | **Scenario 1** | **Pu-239,240 Mobility**



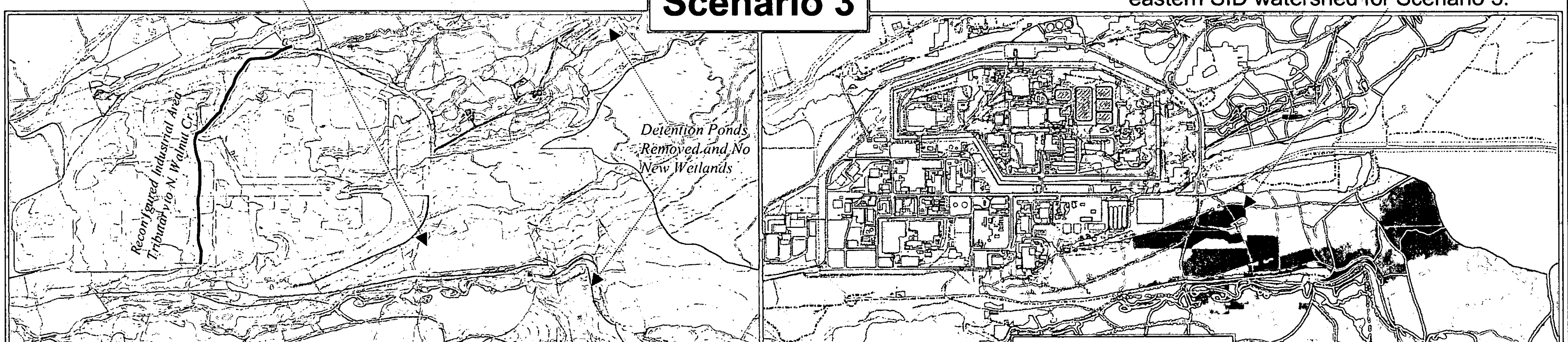
Scenario 1 Features

- Existing Industrial Area tributary to North Walnut Creek
- Existing land surface grade in eastern SID watershed
- Detention ponds and wetlands used to promote actinide settling, reduce actinide mobility

Note: Eastern SID erosion lower for Scenario 3.

Scenario 3

Note: Reduced actinide mobility in eastern SID watershed for Scenario 3.



Scenario 3 Features

- Reconfigured Industrial Area tributary to North Walnut Creek
- Reduced slope of land surface in eastern SID watershed, which also reduces surface soil actinide concentrations
- No wetlands or detention ponds.

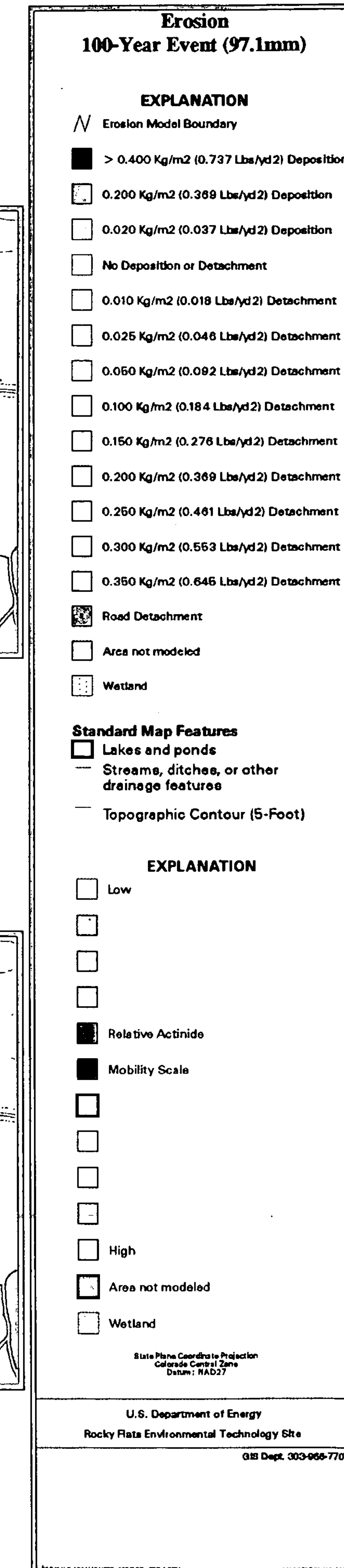
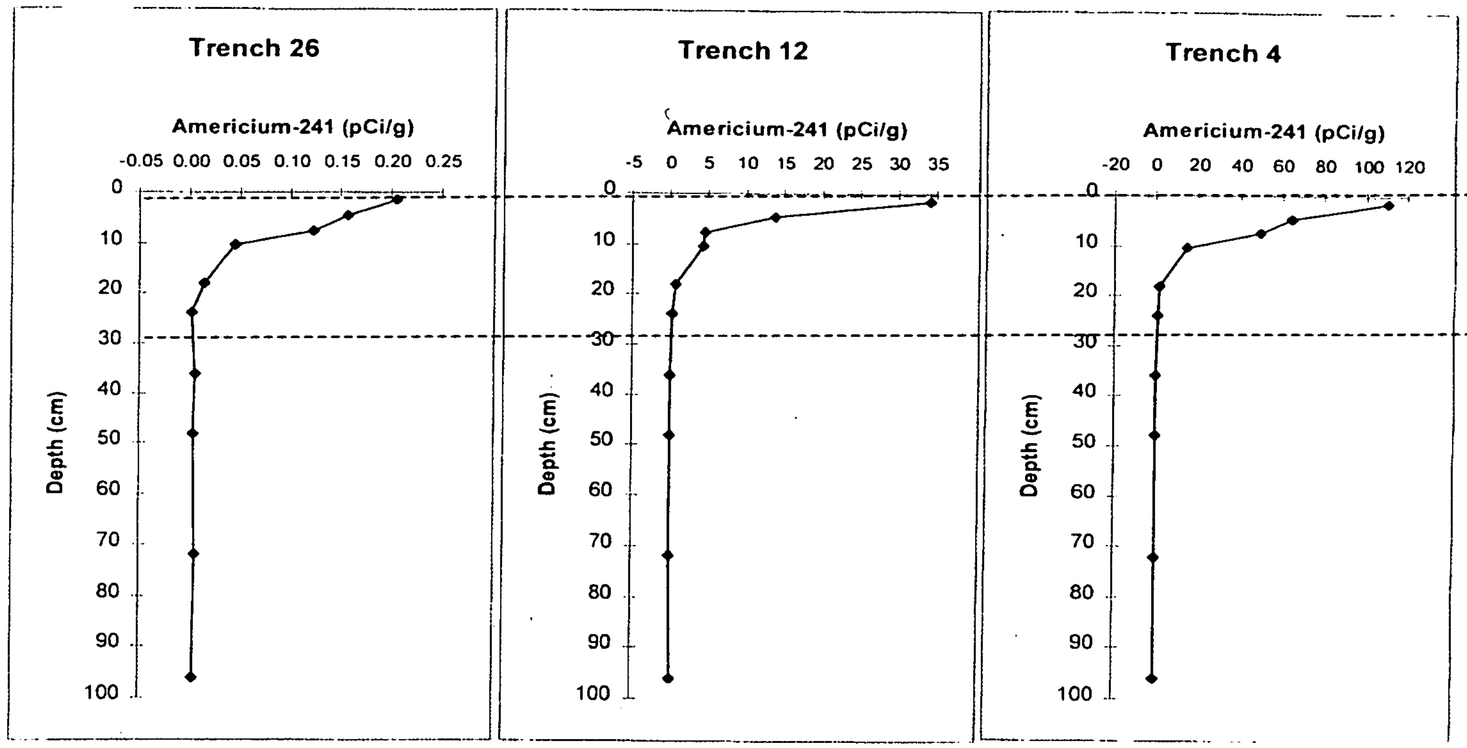
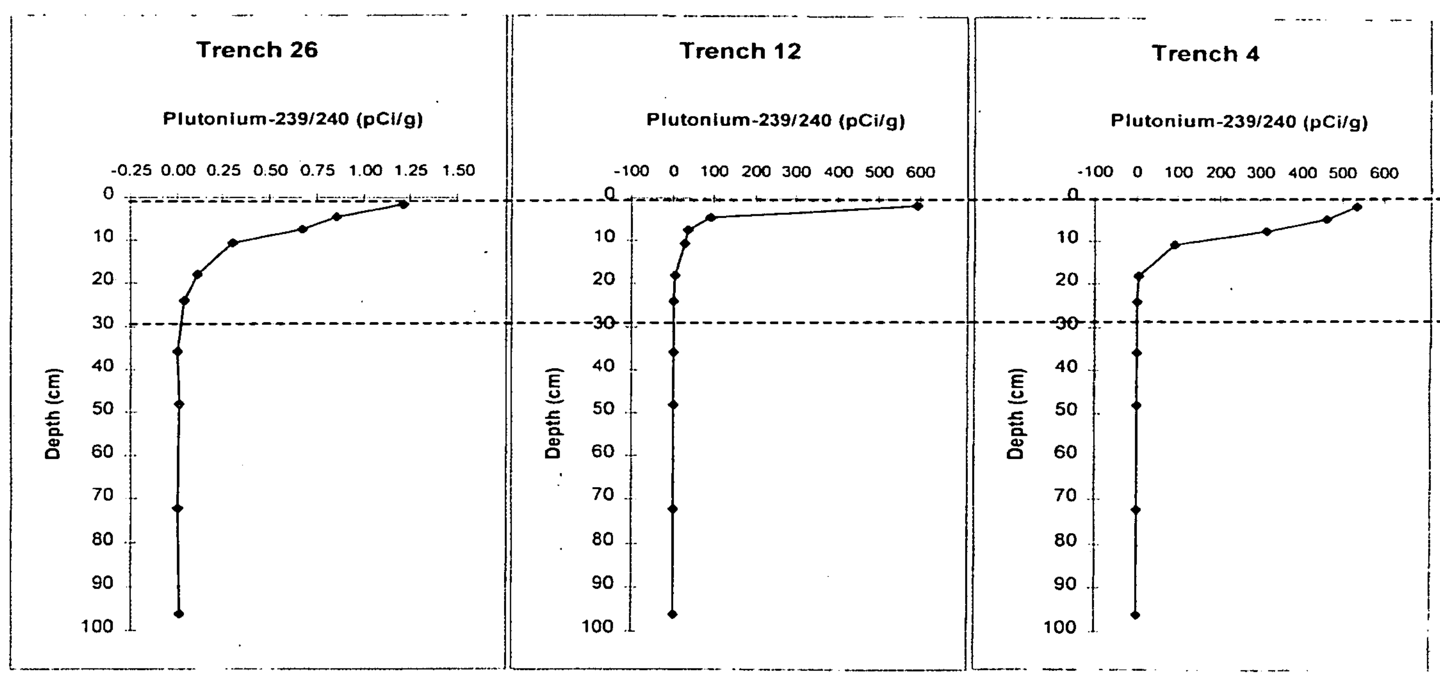


Figure 6. Soil Actinide Concentrations with Depth for Rocky Flats Environmental Technology Site Soil and Conversion to Estimated Tilled (Homogenized) Soil Actinide Concentrations.

Depth Distribution of Americium-241 in Soils Near the 903 Pad



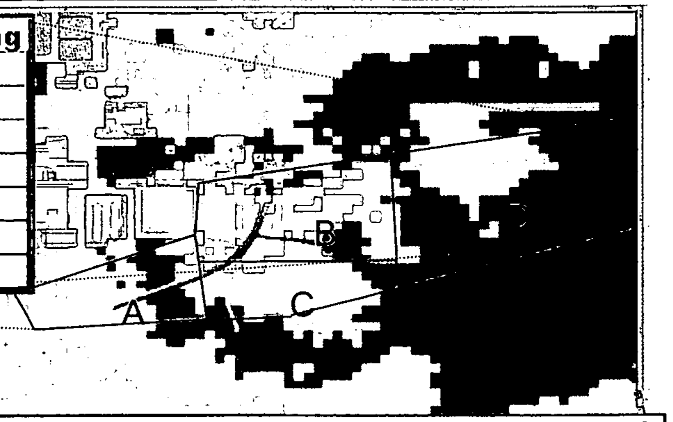
Depth Distribution of Plutonium-239/240 in Soils Near the 903 Pad



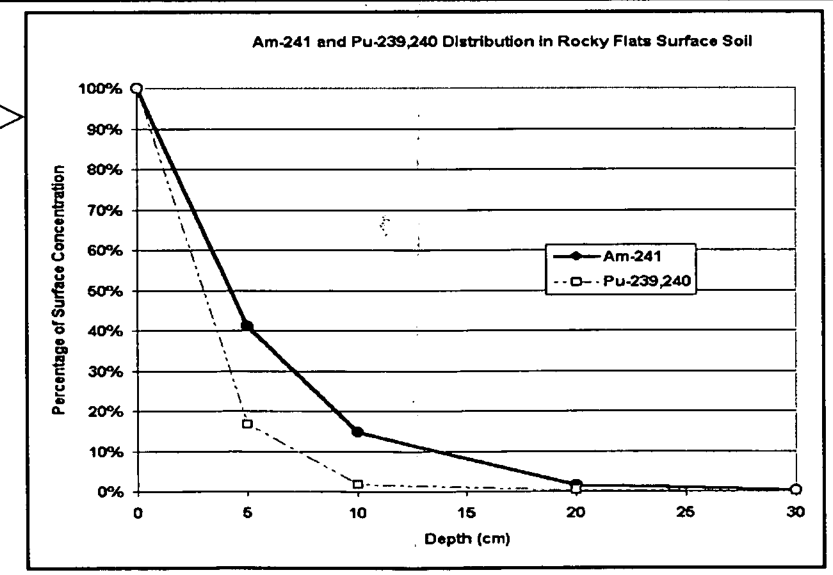
Source: *RF/RMRS-97-074.UN*
Summary of Existing Data on Actinide Migration at the Rocky Flats Environmental Technology Site

Data Source: Litaor et al, 1994 and DOE, 1995.

Sector	Average Existing Pu-239,240 Soil Concentration (pCi/g)	Average Existing Am-241 Soil Concentration (pCi/g)
A	0.51	0.1
B	27.5	4.46
C	9.28	1.28
D	7.99	1.12



Measured distribution of actinides with depth is applied to modified Kriged grid of surface-soil concentration to estimate activity of soil homogenized to a depth of 30 cm. Sectors A, B, C, and D were selected by grouping areas with similar actinide concentrations (by eye).



Homogenized Pu-239,240 Surface-Soil Concentration Grid

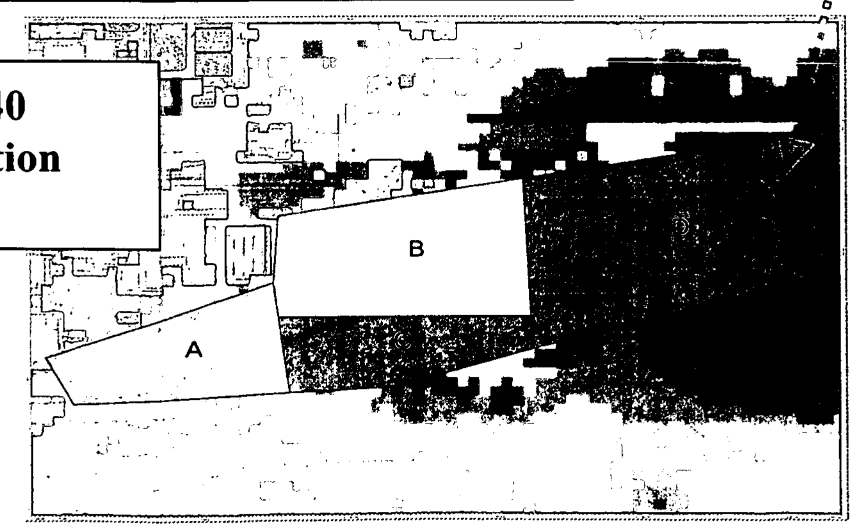


Figure 7. Actinide Isoplot Comparison for Remediated Conditions and Hypothetical Graded SID Watershed Land Surface Woman Creek Scenario 3

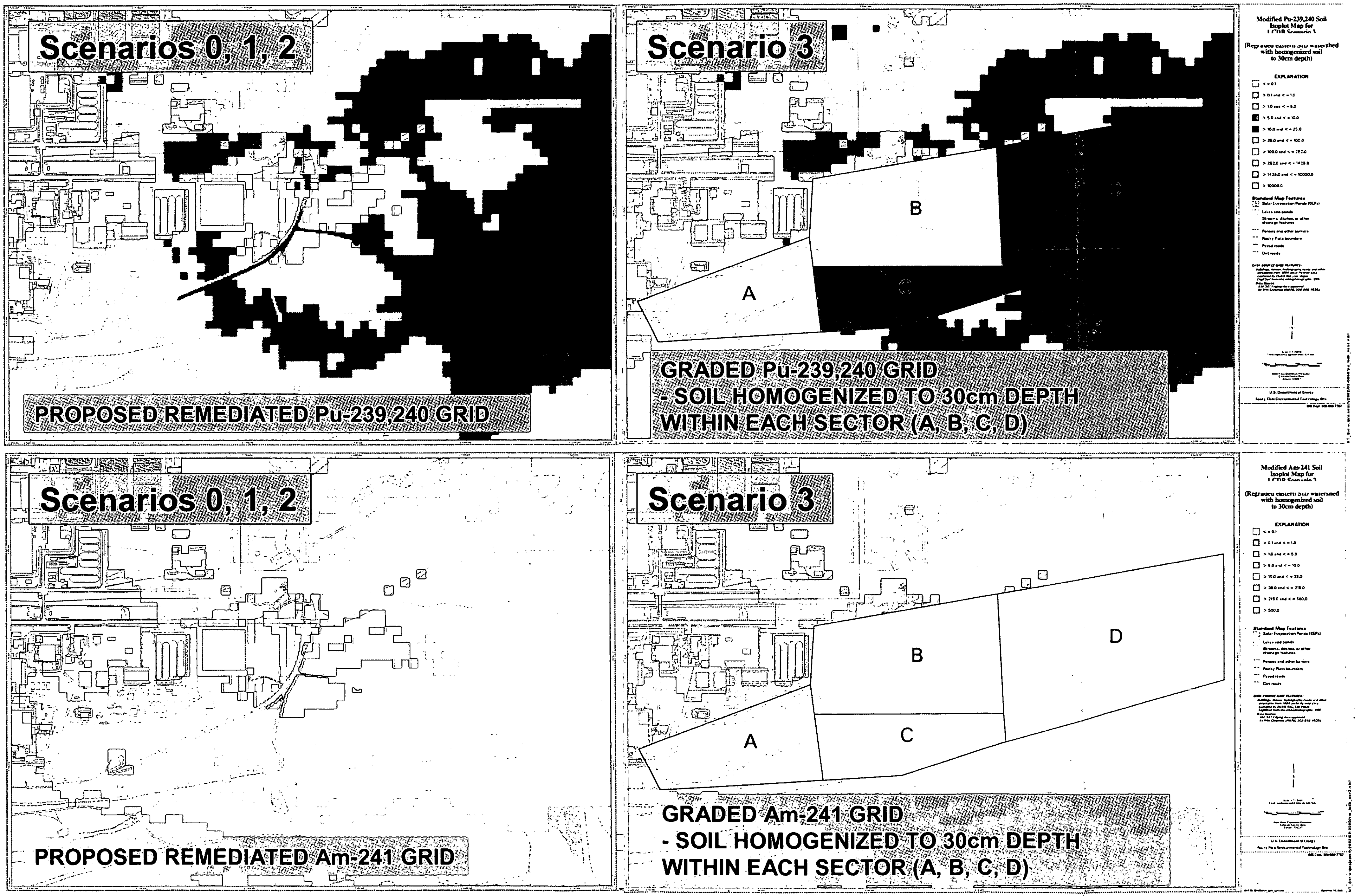


Figure 8. Comparison of Model-Predicted Surface-Water Actinide Concentrations for Proposed Remediated Soil Conditions and a Hypothetical Graded SID Watershed Land Surface - Woman Creek Scenario 3.

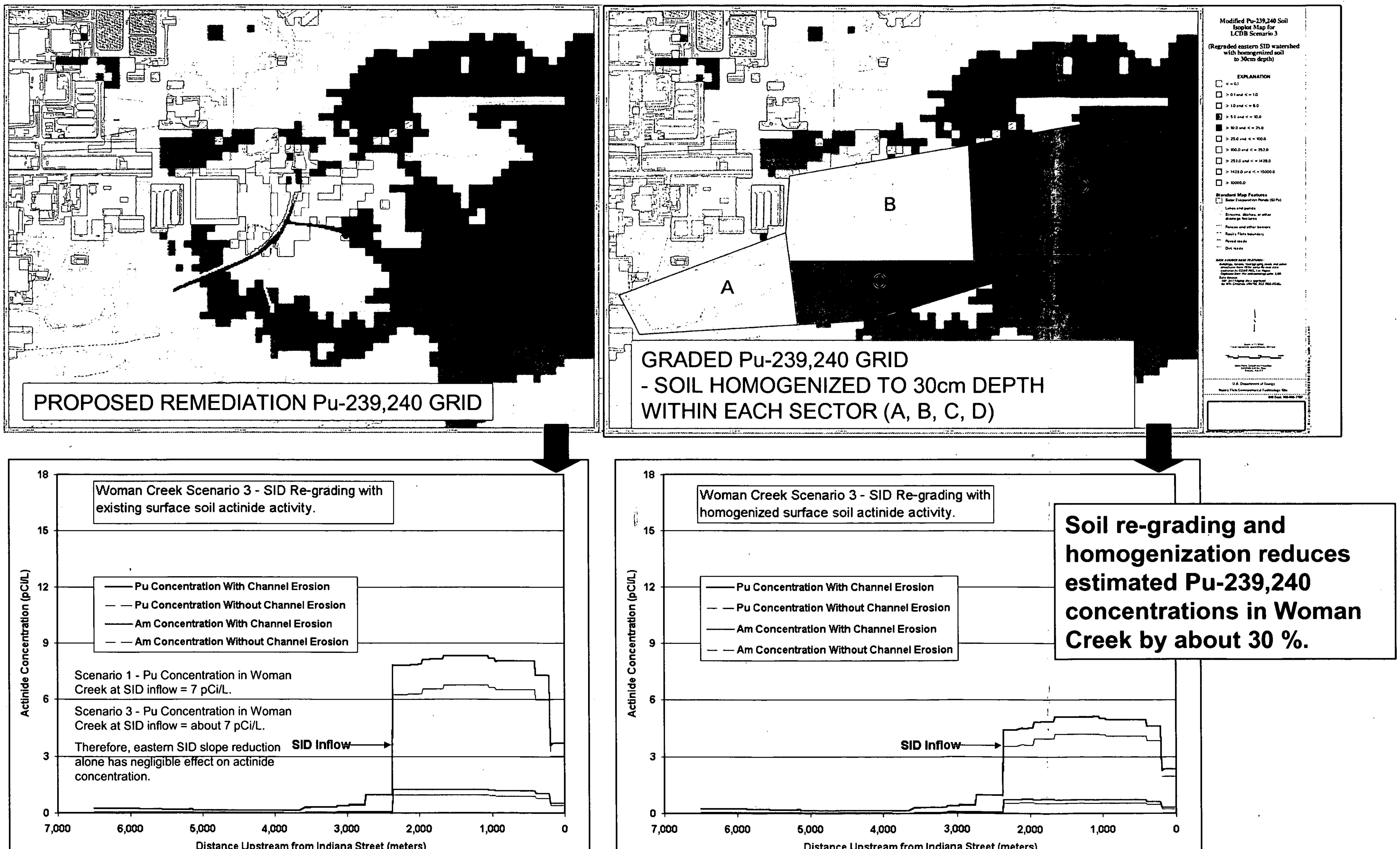
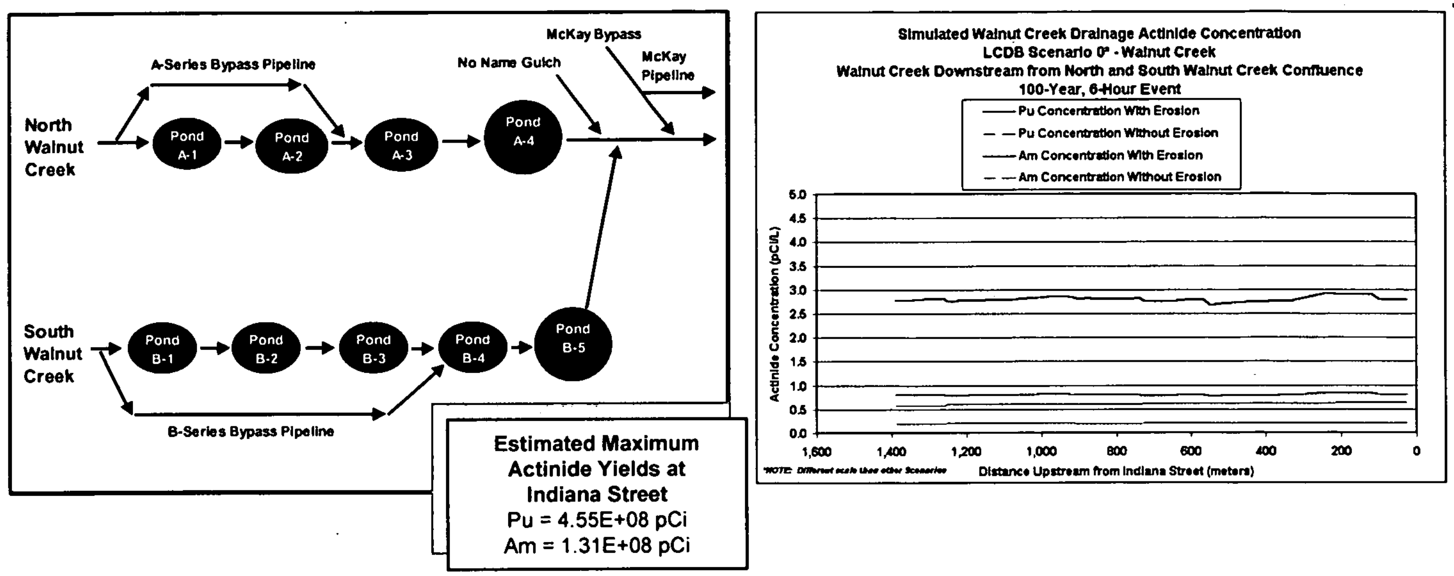
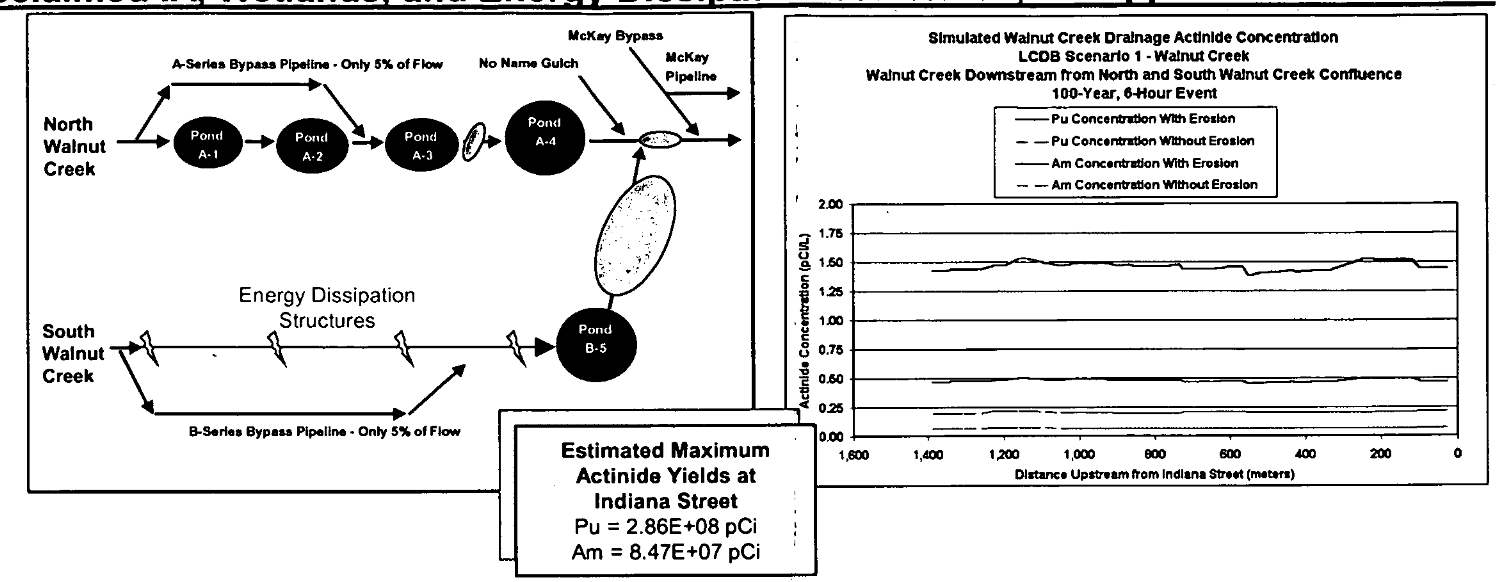


Figure 9. Walnut Creek LCDB Scenarios
Model-Predicted Pu and Am Surface Water Concentrations in Lower Walnut Creek - 100-Year, 6-Hour Storm (97.1 mm)

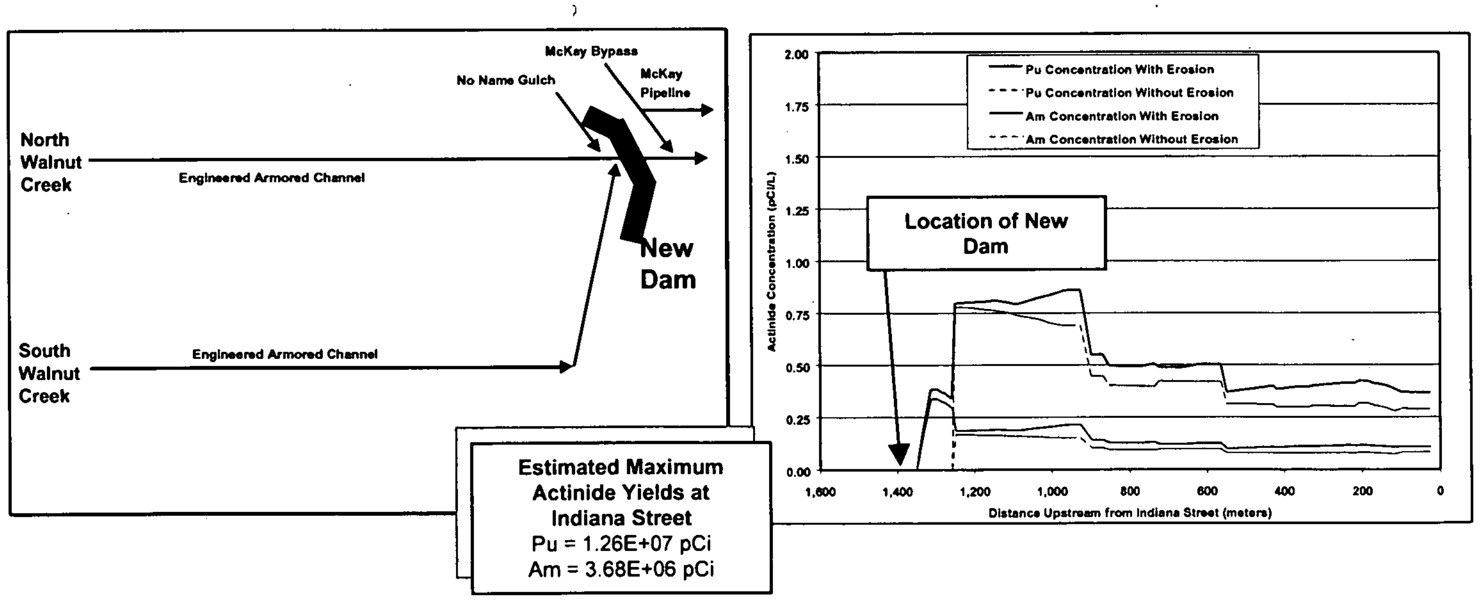
Scenario 0 - Reclaimed Industrial Area



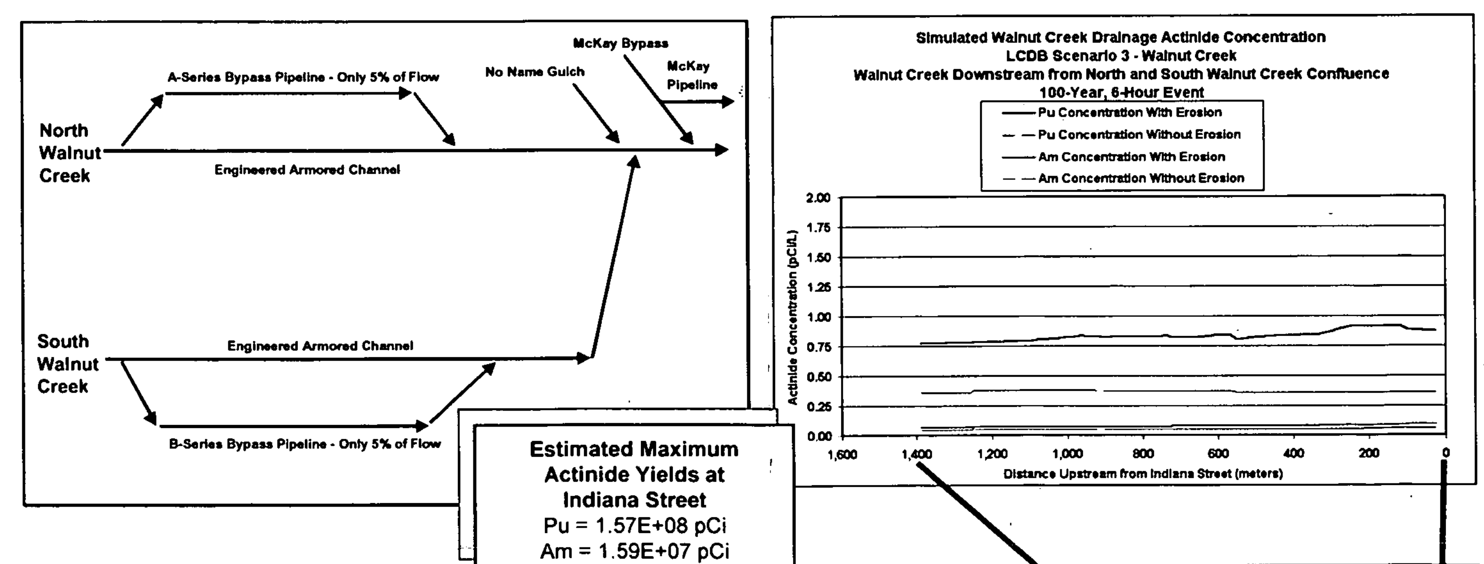
Scenario 1
Reclaimed IA, Wetlands, and Energy Dissipation Structures, No Upper B-Series Ponds

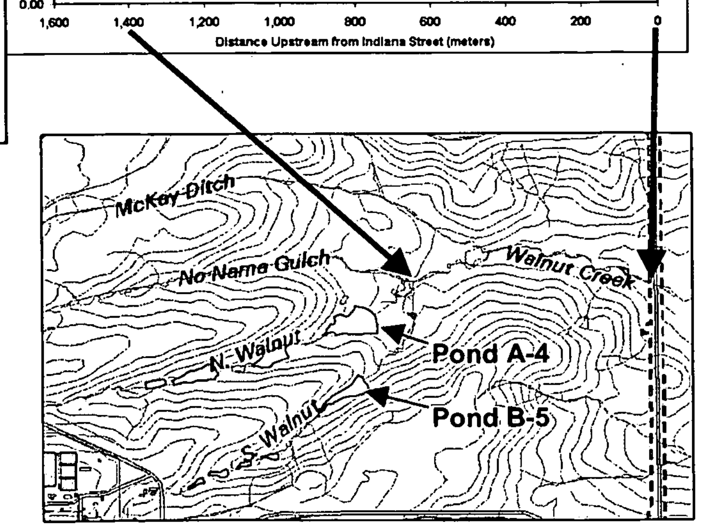


Scenario 2 - New Dam at Confluence of North Walnut Creek and South Walnut Creek



Scenario 3 - Re-Contoured IA, IA Runoff Re-Routed, No Detention Ponds

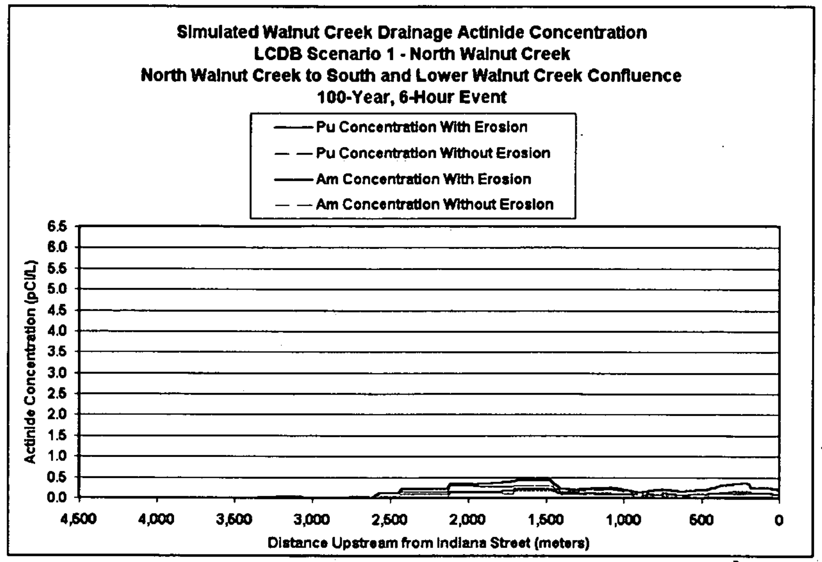


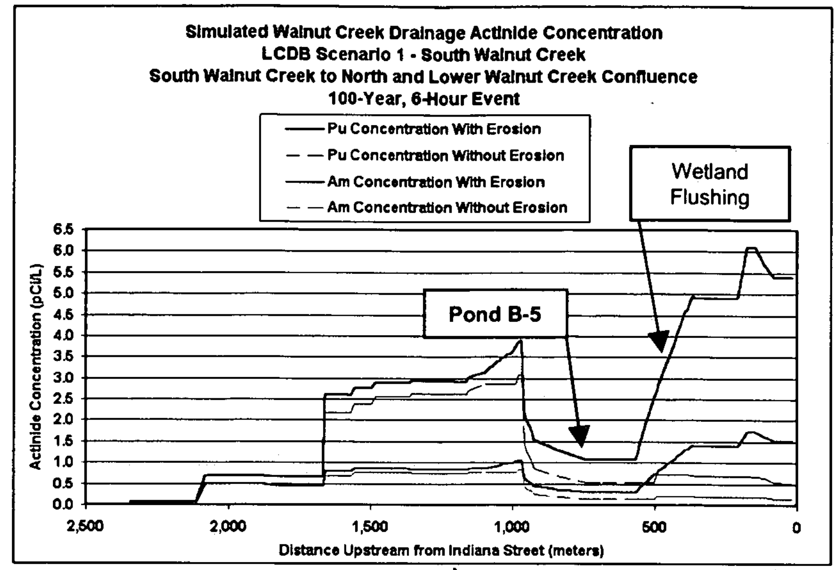


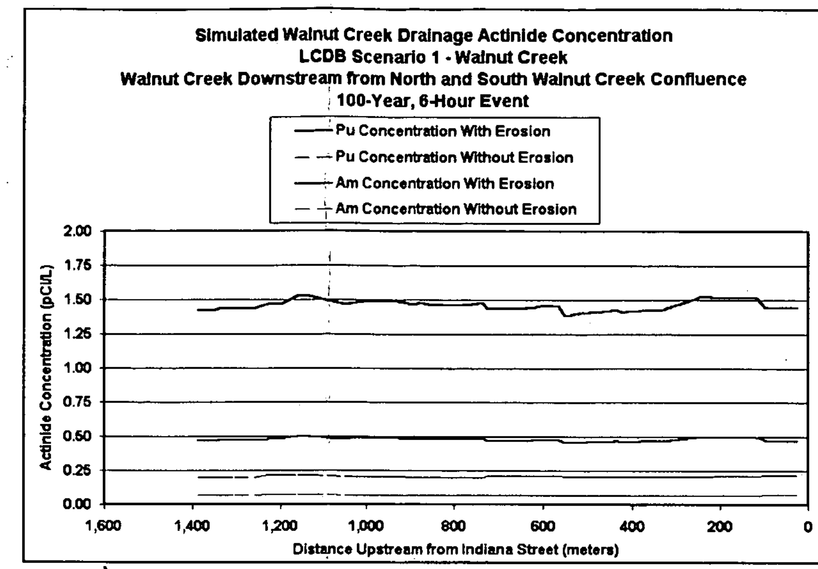
Lower Walnut Creek Location Reference

Figure 10. Walnut Creek LCDB Scenarios 1 and 3
Model-Predicted Pu and Am Surface Water Concentrations in Walnut Creek - 100-Year, 6-Hour Storm (97.1 mm)

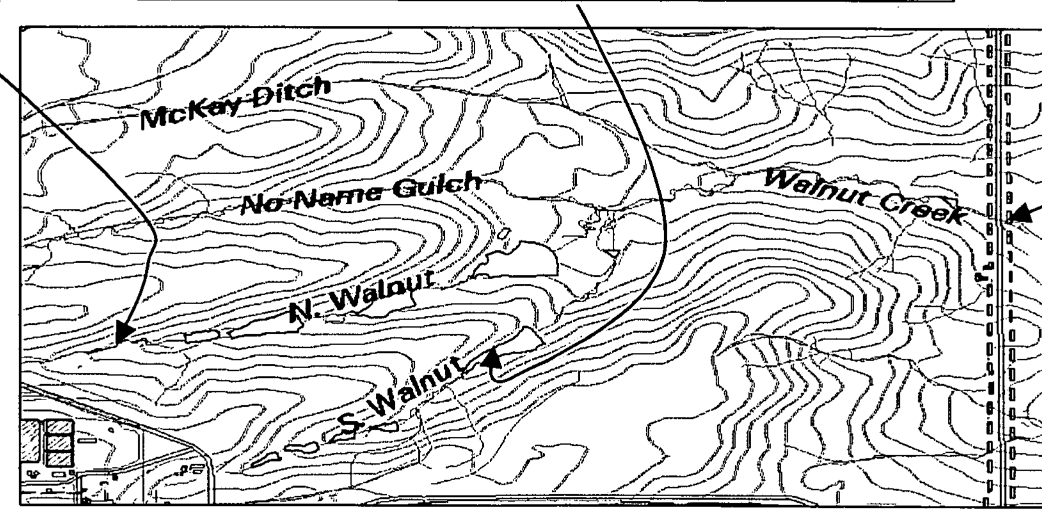
Scenario 1 - Reclaimed IA, Wetlands, and Energy Dissipation Structures, No Upper B-Series Ponds



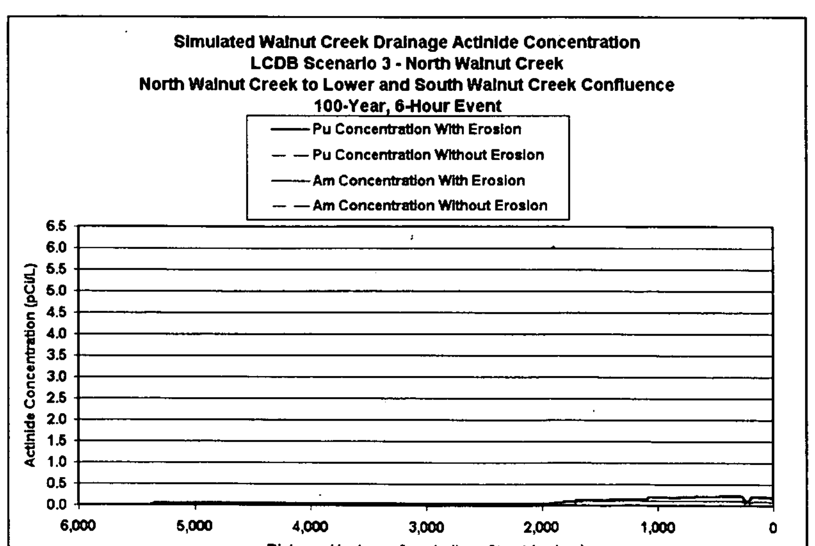


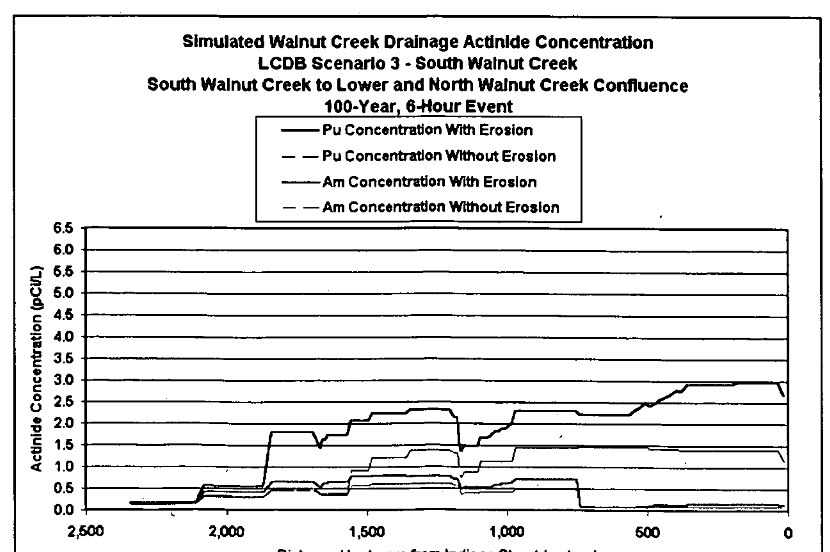


Location Map



Scenario 3 - Recontoured IA, IA Runoff Re-Routed,, No Detention Ponds





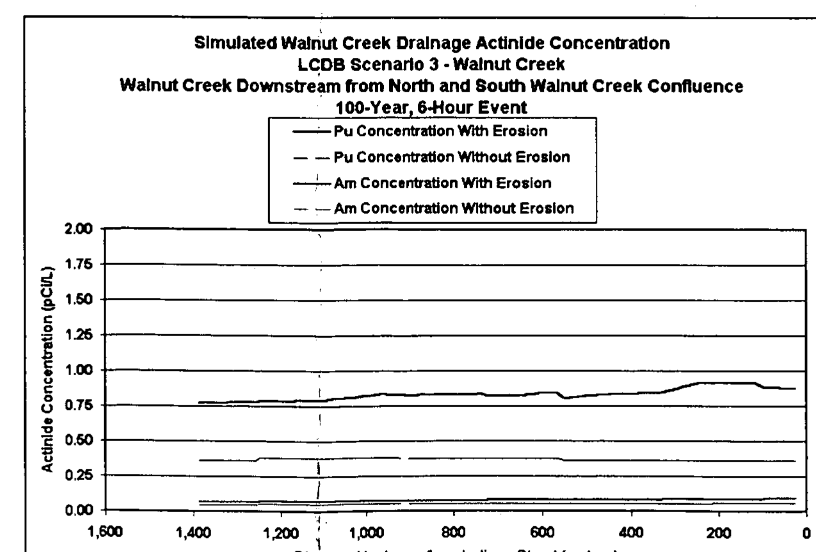
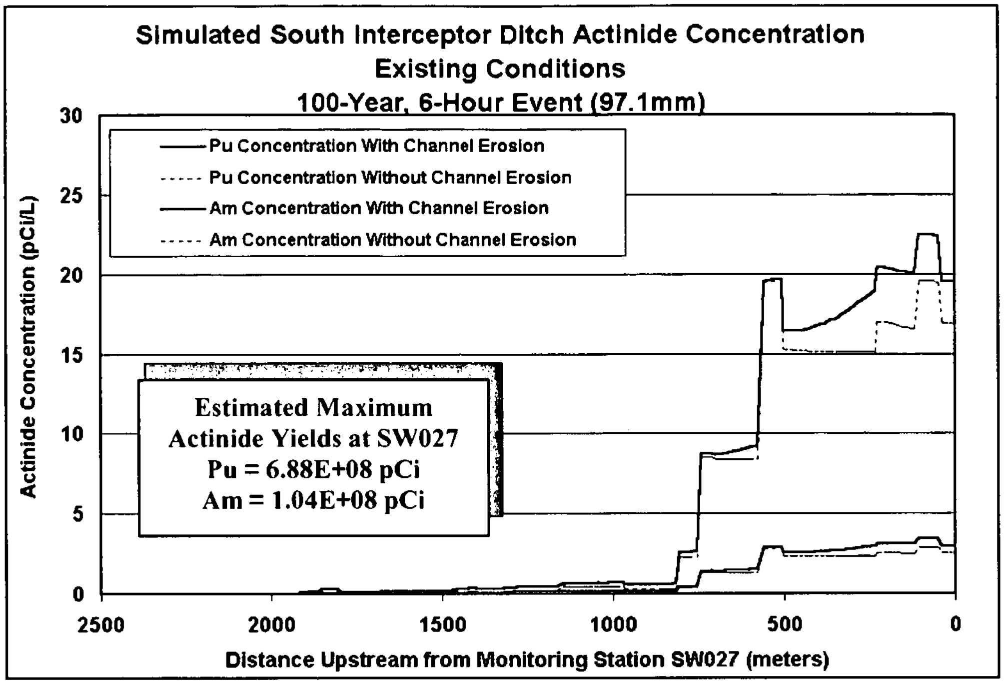


Figure 11. South Interceptor Ditch Scenario Model-Predicted Actinide Concentrations for Existing Conditions and Scenario 0, 100-Year, 6-Hour Storm Event (97.1mm)



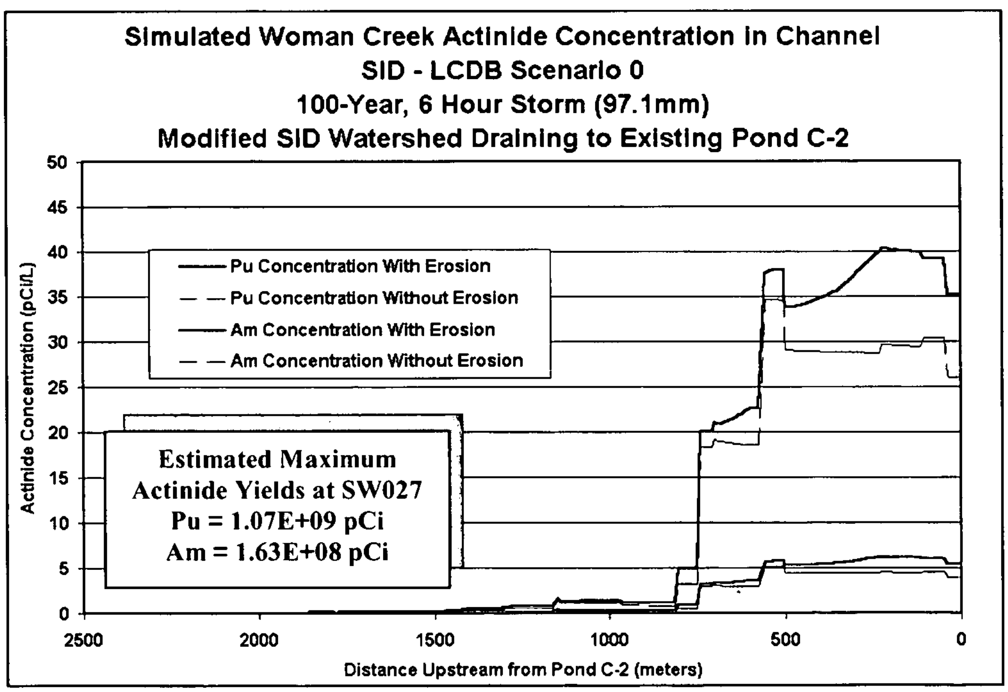
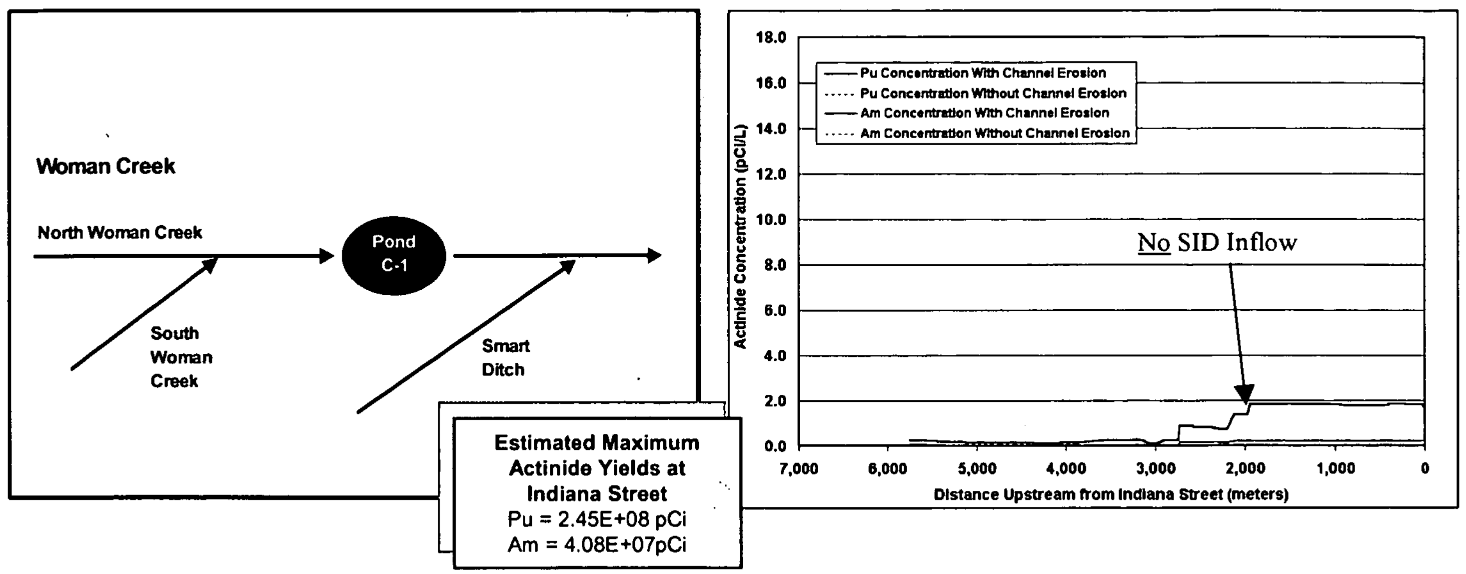
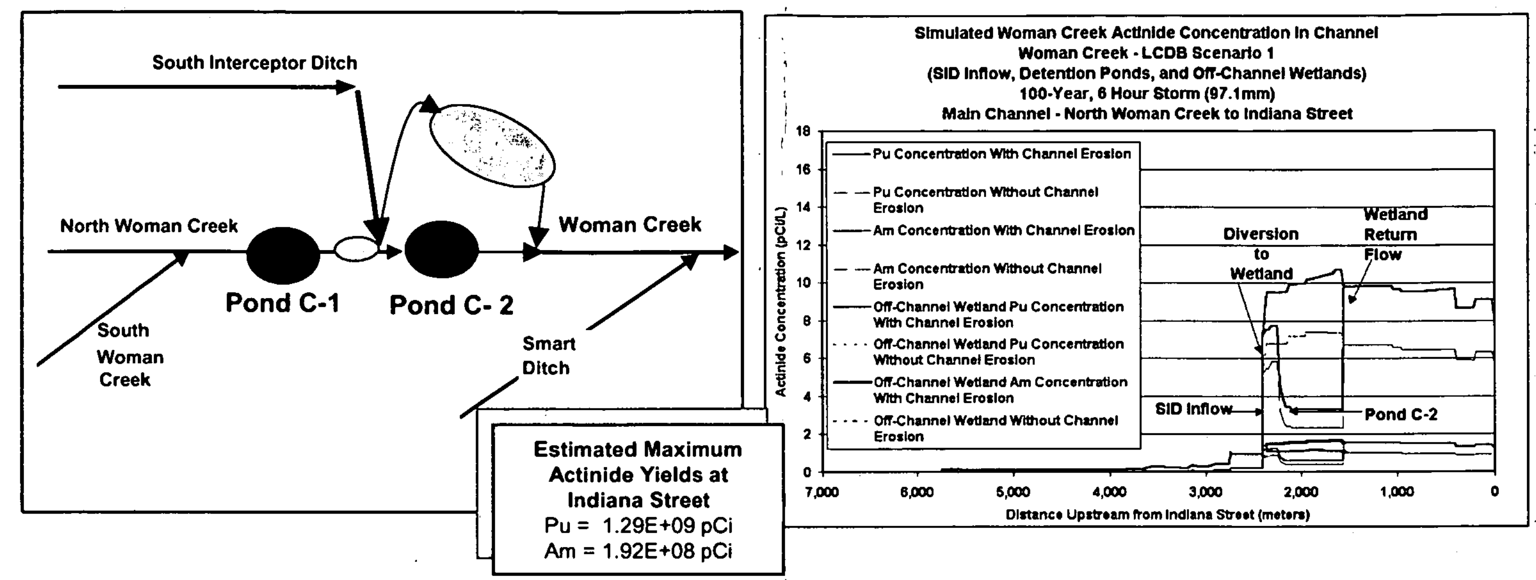


Figure 12. Woman Creek LCDB Scenarios
Model-Predicted Pu and Am Surface-Water Concentrations in Woman Creek - 100-Year, 6-Hour Storm (97.1 mm)

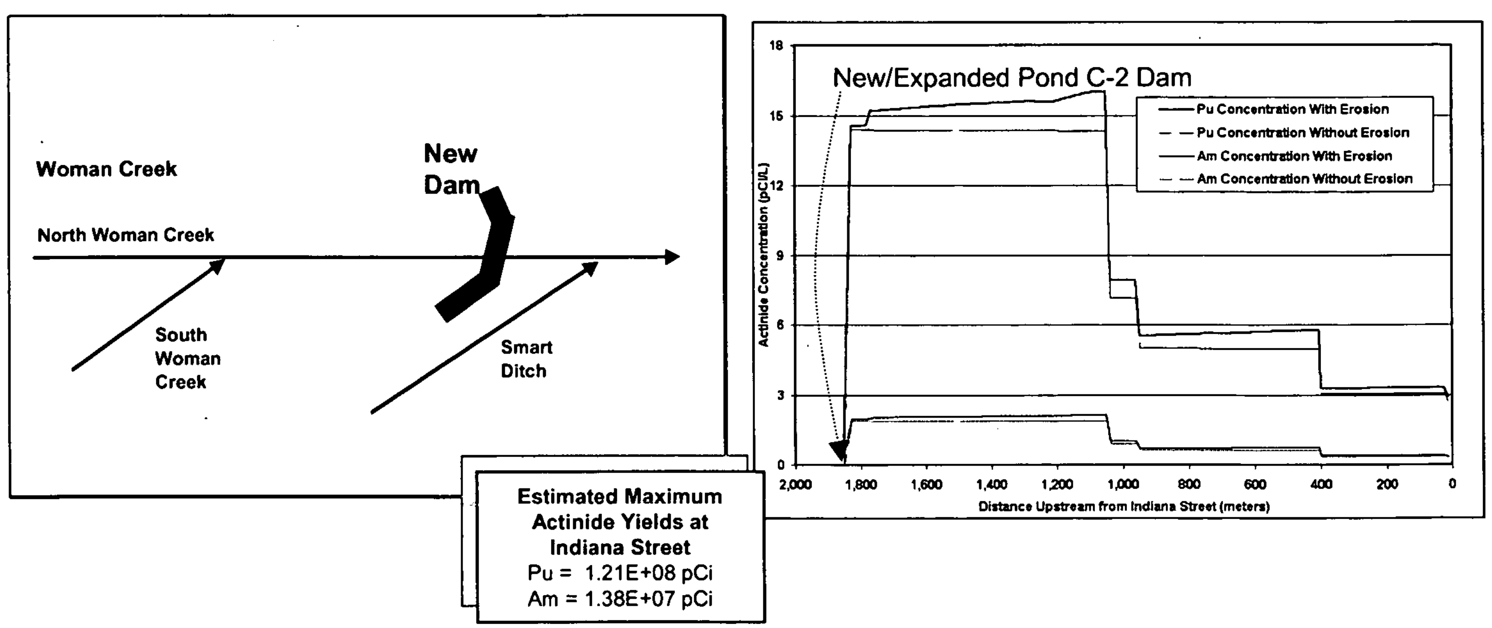
Scenario 0 - Reclaimed / Re-vegetated Industrial Area



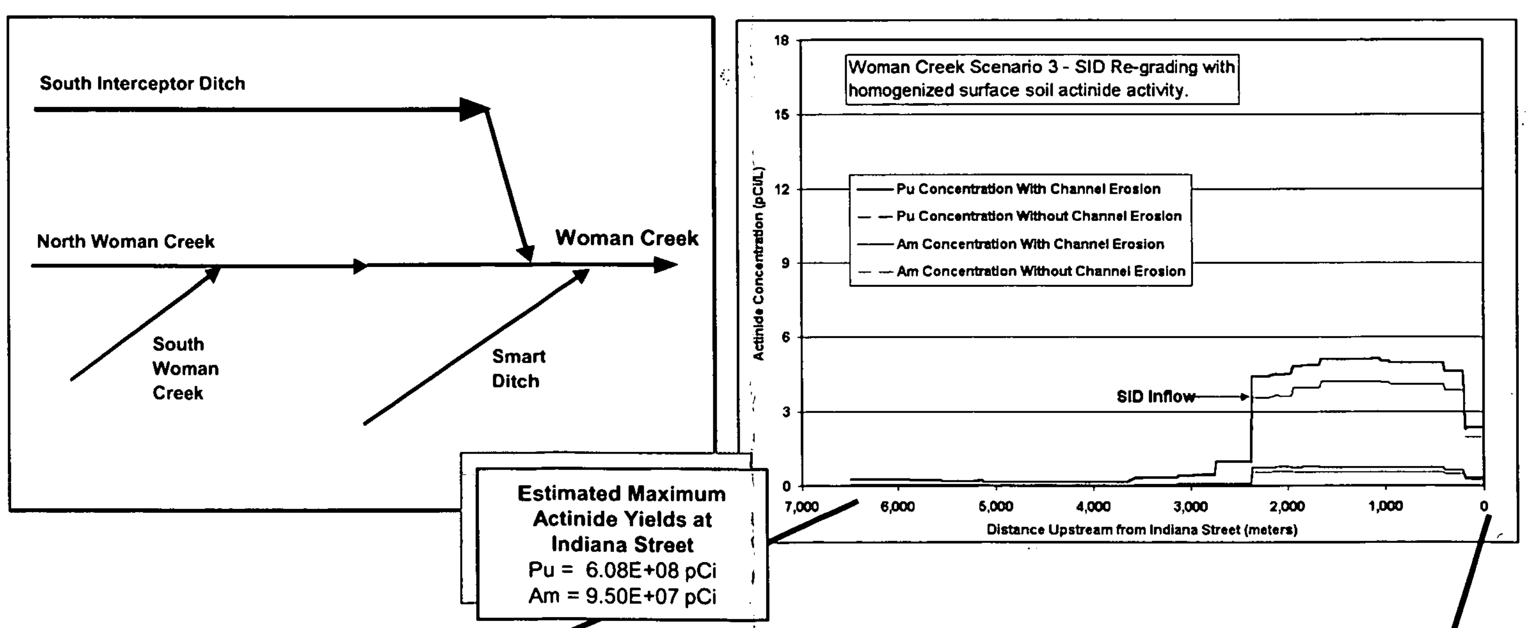
Scenario 1 - SID Routed to Woman Creek, Modified Ponds, and Off-Channel Wetlands



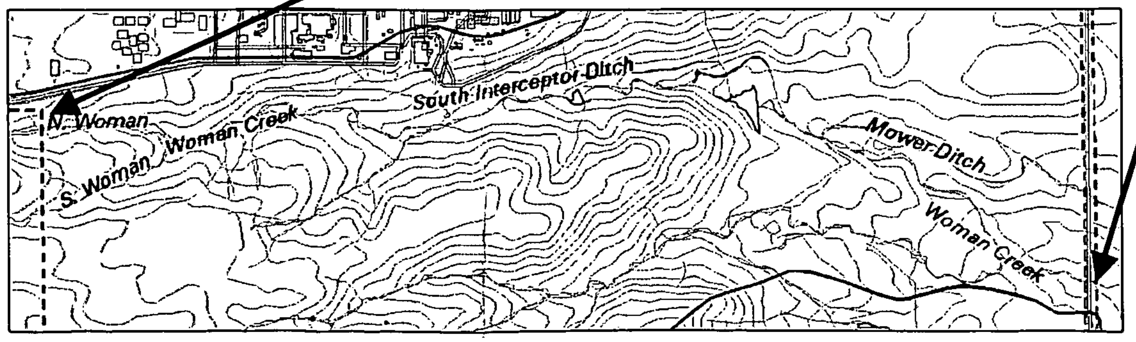
Scenario 2 - Hypothetical Expanded Pond C-2 Dam



Scenario 3 - Regraded SID Drainage Routed to Woman Creek, No Ponds



Woman Creek Location Reference



TABLES

Table 1. Summary of LCDB Scenario Characteristics

Scenario	Industrial Area Configuration	Hydrologic Features	Special Features
0	• Re-vegetated IA • ET Covers on Solar Ponds and Landfills • Re-grade Industrialized Portions of SID drainage	Existing Drainage Features & Routing	None
1	Same as Scenario 0	• Install Engineered Wetlands • Replace Ponds B-1, B-2, B-3, B-4 with Energy Dispersion Structures	• Off-channel wetland in Woman Creek east of Pond C-2 • SID routed to Woman Creek via Pond C-2
2	Same as Scenario 0	Replace all existing detention ponds with one new pond in Walnut Creek and one new pond in Woman Creek.	• SID routed to Woman Creek through new pond
3	• Re-vegetate IA • ET covers on solar ponds and landfills • Realign northern IA tributary to North Walnut Creek.	Replace all existing detention ponds with armored engineered channels Eastern SID watershed re-grading	SID routed directly to Woman Creek Reduced surface-soil actinide concentrations in eastern SID due to re-grading.

IA = Industrial Area, SID = South Interceptor Ditch, ET = Evapotranspiration

Table 2. Summary of Results for LCDB Scenario Modeling

Scenario	Watershed	Gaging Station	POE or POC	Estimated Runoff (m^3)	Estimated Sediment Yield[1] (kg)	Estimated Range Pu Concentration (pCi/L)	Estimated Range Am Concentration (pCi/L)	Estimated Range Pu Yield (pCi)	Estimated Range Am Yield (pCi)
Existing	Walnut Creek	SW093	POE	64,175	27,667	0.121 - 0.151	0.122 - 0.142	7.76E+06 - 1.02E+07	7.84E+06 - 9.33E+06
Existing	Walnut Creek	GS10	POE	68,914	4,975	0.06 - 0.065	0.07 - 0.076	4.14E+06 - 4.54E+06	4.82E+06 - 5.21E+06
Existing	Walnut Creek	GS08	POC	91,832	19,827	0.13 - 0.43	0.04 - 0.17	1.12E+07 - 3.70E+07	3.49E+06 - 1.47E+07
Existing	Walnut Creek	GS03	POC	254,271	257,543	0.14 - 0.64	0.04 - 0.25	3.61E+07 - 1.65E+08	1.12E+07 - 6.48E+07
Existing	Woman Creek	GS01	POC	145,923	113,219	1.72 - 1.75	0.203 - 0.204	2.11E+08 - 2.45E+08	2.39E+07 - 4.08E+07
Existing	SID	SW027	POE	37,842	106,084	16.9 - 19.5	2.5 - 3.0	6.39E+08 - 7.37E+08	9.52E+07 - 1.12E+08
0	Walnut Creek	SW093	POE	23,758	34,601	0.31 - 0.36	0.13 - 0.16	7.30E+06 - 8.54E+06	3.10E+06 - 3.69E+06
0	Walnut Creek	GS10	POE	14,917	7,454	2.7 - 3.2	0.74 - 0.86	4.00E+07 - 4.69E+07	1.11E+07 - 1.29E+07
0	Walnut Creek	GS08	POC	32,009	21,798	1.4 - 3.3	0.44 - 0.93	**4.56E+07 - 1.15E+08**	**1.40E+07 - 3.23E+07**
0	Walnut Creek	GS03	POC	163,314	264,789	0.64 - 2.8	0.21 - 0.80	**1.05E+08 - 4.55E+08**	**3.46E+07 - 1.31E+08**
0	Woman Creek[2]	GS01	POC	145,923	113,219	1.72 - 1.75	0.203 - 0.204	2.11E+08 - 2.45E+08	2.39E+07 - 4.08E+07
0	SID	SW027	POE	30,429	90,431	26 - 35	3.9 - 5.4	8.56E+08 - 1.07E+09	1.28E+08 - 1.63E+08
1	Walnut Creek	SW093	POE	25,121	34,601	0.29 - 0.34	0.12 - 0.15	7.00E+06 - 8.20E+06	2.89E+06 - 3.47E+06
1	Walnut Creek	GS10	POE	14,917	7,472	2.2 - 2.6	0.68 - 0.80	3.27E+07 - 3.88E+07	1.01E+07 - 1.19E+07
1	Walnut Creek	GS08	POC	37,596	10,463	0.54 - 1.3	0.16 - 0.36	**1.72E+05 - 4.06E+07**	**5.04E+06 - 1.16E+07**
1	Walnut Creek	GS03	POC	162,562	247,878	0.23 - 1.8	0.08 - 0.52	**3.82E+07 - 2.86E+08**	**1.22E+07 - 8.47E+07**
1	Woman Creek	GS01	POC	175,102	247,937	5.7 - 7.4	0.85 - 1.1	1.01E+09 - 1.29E+09	1.49W+08 - 1.92E+08
1	SID	SW027	POE	30,141	99,210	26 - 32	3.9 - 4.9	7.96E+08 - 9.72E+08	1.18E+08 - 1.46E+08
2	Walnut Creek	GS03	POC	38,655	59,745	0.29 - 0.37	0.08 - 0.11	1.11E+07 - 1.42E+07	3.19E+06 - 4.17E+06
2	Woman Creek	GS01	POC	42,006	36,206	2.7 - 2.9	0.30 - 0.33	1.12E+08 - 1.21E+08	1.26E+07 - 1.38E+07
2	SID[3]	SW027	POE	*30,429*	*90,431*	*26 - 35*	*3.9 - 5.4*	*8.56E+08 - 1.07E+09*	*1.28E+08 - 1.63E+08*
3	Walnut Creek	SW093	POE	39,514	34,496	0.04 - 0.05	0.02 - 0.03	1.5E+06 - 1.84E+06	1.09E+06 - 9.60E+05
3	Walnut Creek	GS10	POE	14,151	6,079	0.34 - 1.6	0.38 - 0.61	4.88E+06 - 2.32E+07	5.36E+06 - 8.63E+06
3	Walnut Creek	GS08	POC	32,029	34,423	1.4 - 2.3	0.05 - 0.07	4.65E+07 - 7.24E+07	1.69E+06 - 2.33E+06
3	Walnut Creek	GS03	POC	180,005	308,630	0.36 - 0.87	0.06 - 0.09	6.43E+07 - 1.57E+08	1.05E+07 - 1.59E+07
3	Woman Creek	GS01	POC	334,171	137,574	1.4 - 1.8	0.21 - 0.28	4.71E+08 - 6.08E+08	6.96E+07 - 9.50E+07
3	SID	SW027	POE	30,366	74,134	16 - 21	2.8 - 3.8	4.78E+08 - 6.39E+08	8.45E+07 - 1.15E+08

Energy Dissipation Structures Decrease Actinide Yield to GS08 by About <u>70%</u>

Wetlands Decrease Actinide Yield to GS03 by About <u>94%</u>

SW093 = North Walnut Creek above Pond A-1
GS01 = Woman Creek at Indiana Street
GS10 = South Walnut Creek above Pond B-1
GS08 = South Walnut Creek below Pond B-5
SW027 = South Interceptor Ditch at Mouth above Pond C-2
GS03 = Walnut Creek at Indiana Street
POC = Rocky Flats Cleanup Agreement Surface Water Point of Compliance; POE = Rocky Flats Cleanup Agreement Surface Water Point of Evaluation

[1]Value includes sediment yield due to channel erosion (scour).

[2]Same as existing conditions.

[3]Same as Scenarios 0 and 1. Note that SID yields to Woman Creek are larger than Yields in Woman Creek, indicating removal of SID actinide load in Pond C-2.

APPENDIX A

WEPP Modeling Review and Meeting Summaries

June 28, 2001

Review of Scenario 0 Erosion and Runoff Modeling for the Industrial Area (IA)

The overall impression is that the input and output are consistent with the previous Actinide Migration Evaluation (AME) Erosion Modeling Report. The results of the review are detailed in the following bullets.

- Soil and vegetation input parameters were checked and were consistent with the previous AME WEPP modeling. I was unable to verify the slope values from the *.dbf files that were sent and I do not have a topographic map of the Site after final remediation, but the transect lines appear reasonable and well placed.
- I have two comments on the delineation of hillslopes: 1) There may be more hillslopes than necessary for the resolution of the model; 2) It appears that many of the hillslopes drain onto other hillslopes, not into drainages. This may make estimating amounts of sediment and actinides reaching surface water difficult. I have not been involved in the process, so this may have been discussed and an approach decided upon previously. If an approach has not been decided upon, this should be discussed with the HEC-6T modeler immediately.
- The hillslope models were run and the output checked against the tables provided by Parsons. Five hillslopes were found to have discrepancies in runoff and/or sediment yield when compared to the table "modelvalid2.xls." Four hillslopes, 217, 218, 224, and 225 had lower Ke's than in the table. The Ke's in the table were in red perhaps indicating that they were to be changed. The table, soil files, and out put should be reconciled. The "Sediment Originating in the OFE" result for hillslope 128, OFE B, in the table did not have the sediment value for OFE A subtracted from it. This should be corrected.
- The footnotes for the tables for the other watersheds were not consistent and should be updated if these tables are distributed more widely.
- Summary statistics for runoff and sediment output were calculated for the model and the three other watersheds and used to determine if the model output for Scenario 0 was consistent with output for the three previously modeled watersheds. The Excel file, "Model review.xls" is attached. The first spreadsheet has the mean, standard deviation, maximum, minimum and median values for runoff (mm), sediment originating in the OFE (kg/m), sediment yield (kg/ha), and slope (m/m) for the topslope and sideslope soils for the four modeled areas. The second sheet is a graph of runoff versus slope and the third is sediment yield versus slope. It is recognized that neither independent variable is solely related to slope, but the results are helpful for deciding if the four modeled areas are behaving similarly. I am satisfied that the results of the Scenario 0 IA model are reasonable.

July 13, 2001

Review of Scenario 0 Erosion and Runoff Modeling for the South Interceptor Ditch (SID) and Current Landfill (CLF)

South Interceptor Ditch Review

The input and the output for the SID hillslopes are inconsistent with the previous Actinide Migration Evaluation (AME) Erosion Modeling Report. Figure one shows a comparison of runoff and sediment loss for the original configuration and the modified SID hillslopes. The figure clearly shows that on several hillslopes (especially 1, 6, 10, 12, 13 15) sediment loss has increased dramatically while runoff is generally lower.

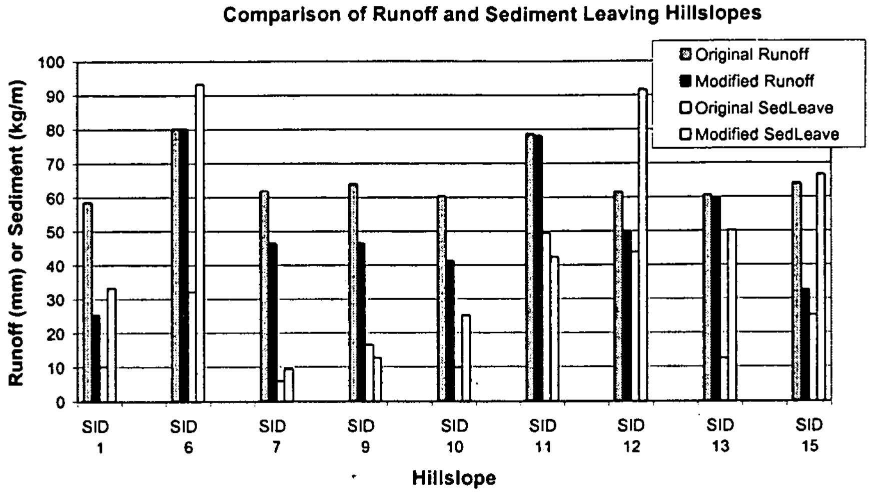


Figure 1

The results of the review are detailed in the following bullets.

- It is the opinion of the reviewer that changing management and slope files on OFEs that have not been altered due to addition of covers (e.g. the old landfill) or removal of buildings and the addition of area at the top of the slope have nothing to do with the changes in land configuration and make it very difficult, if not impossible, to identify the effects of the important changes (building removal etc). Ii is suggested that the SID hillslopes be modeled with only the modifications that are truly necessary, using the original SID single-storm hillslope management slope and soil input files as the base for the modified input files. Figure 1 illustrates the problems created by using completely new hillslope files. Tracking down the causes is time consuming. The following bullets discuss some of the causes.

- Soil and vegetation input parameters were checked and were consistent with the previous AME WEPP modeling, although vegetation type was changed on some OFEs. There were two exceptions: 1). The random roughness variable in the soil file for SID6m was changed from 0.02 to 0.01. Runoff and sediment loss are sensitive to this parameter and it was probably increased in the original model on this hillslope to calibrate the hillslope. 2) The rill basal cover for the xeric tall grass prairie vegetation inputs is 0.035. This value agrees with Table A-3 in the AME Erosion Report but all Walnut Creek hillslopes have a value of 0.05. You might want to check with Greg Wetherbee and see if the 0.05 value is an update that should be used throughout the modeling.

- There appears to be some problems with slope values: 1) Sediment leaving Hillslope 1 has more than tripled. The slope on OFE 4 seems excessive. The slope for the first two-thirds of the OFE is between 36 % and 40%. This may be necessary for the landfill cover design. If so, it demonstrates the need for applying erosion control such as armoring to the steep slope. 2) Sediment leaving Hillslope 6 has almost tripled. This appears to be the result of a 50% slope over 25% of the distance (from slope file:0.000,0.157 0.250,0.157 0.500,0.509 0.750,0.099 1.000,0.111). It doesn't look like the road was modified, therefore, the original files for SID6 could be used and results would be consistent. 3) In the original slope files for the SID the flow was routed across the roads that were OFEs (e.g. SID1, SID10, SID 12, SID 13, and SID15). Therefore, the road OFEs were kept to 3 to 5 meters in length and set at a lower slope value than the hillslope (Example: SID1m has a road 30 meters wide). To facilitate the evaluation of important changes in land configuration, it is suggested that road widths be kept reasonable and the slope values used in the original SID modeling be used when available, unless the hillslope has been graded significantly.

- Some of the problems with decreased runoff and increased erosion shown in Figure 1 are due to a model interaction with slope length (i.e. long slope lengths).The AME Modeling Project had previously identified this as an artifact of the WEPP model. The developers were consulted but the problem persists. This is a problem with the model that can be worked around. It is possible that by increasing the number of OFEs, thereby decreasing the lengths of the long OFEs the runoff and erosion could be brought in line with the original model. Another fix might be to model the long top-slope areas as separate hillslopes and then add the runoff and erosion results to the areas below. This appears to be a problem on Hillslopes 1, 7, 9, 10, 12, and 15 (and maybe 13).

  An example is that the sediment leaving Hillslope 10 has increased by more than a factor of 2.5 while runoff is decreased by one third. Reducing the lengths of OFEs 1 and 2 to 24 and 49 meters, respectively, with the lengths of other OFEs unchanged produced the results below. These results are very similar to the original SID results for both runoff and erosion. The results would be even closer if the slope of the unimproved road were changed to that of the original.

		-------Modified------------		--------Original------------	
OFE	Precip	Runoff	SedLeave	Runoff	SedLeave
	mm	mm	kg/m	mm	kg/m
1	97.1	58.941	0.122	----	---
2	97.1	57.164	1.384	9.288	.334
3	97.1	57.787	5.076	9.057	.250
4	97.1	58.333	6.544	9.591	.086
5	97.1	59.014	2.699	0.472	.953

- In summary, it is suggested that, in order to facilitate comparison to the original SID model and to understand the effects of the important land configuration changes, the original SID single-storm hillslope input files be used with changes incorporated only as a result of proposed Site configuration alterations. It may also be necessary to model the long Hillslopes in more than one segment or add OFEs to compensate for the instability of the WEPP model on long hillslopes.

Present Landfill Review

The proposed configuration of the Present Landfill makes it a difficult area to model for runoff and erosion. The cap drains in three directions and is circumscribed by a road.
The current hillslope model for the Present Landfill is not very meaningful from a watershed modeling perspective.

Conceptually OFEs are planes that drain from one to the next and decrease in elevation. In the current model OFE 1 is in reality at the base of the slope but is modeled at the top of the slope. It seems more reasonable to designate the current OFE 2 as the top or first OFE.

The model should be reconfigured after an analysis is done to determine the most-likely drainage patterns. The question to be answered is: How much runoff and sediment will reach the drainage at the eastern end of the landfill and where does it originate? The current model does not provide the answer to this question.

August 19, 2001

Review of Scenarios 1, 2, and 3.

In general the WEPP output looks reasonable. There are a couple of concerns, based on a limited review of the input text files and the graphics that were provided.

1. I do not have the information of tools necessary to state with certainty that the changes in the hillslopes are reflective of the scenarios. I suggest that RFETS GIS personnel familiar with the previous model examine the hillslope configuration data and scenario configuration changes. Greg Wetherbee and/or I can then review their findings.

2. In Scenario 2 it appears that in Woman Creek hillslopes 31, 32, 33, and 35 have been kept intact although in this scenario a dam or a drainage swale splits them. If the hillslopes are indeed split by proposed features that will greatly influence surface drainage patterns they should be reconfigured to reflect the changes. New hillslope may need to be designated.

3. In Scenario 3 the hillslope configurations for the SID area do not appear to be consistent with the Scenario description. A review of the WEPP input files indicates that the IA positive drainage and the grade reduction for the SID area have been incorporated. However drainage improvements and controls have not been incorporated into the WEPP model for the SID.

General Comments

None of the WEPP hillslope input files for the three scenarios have been named or annotated to describe to which Scenario they specifically apply. For example, the slope files for hillslopes that change attributes between scenarios all have the same name. The files should be renamed and annotated or there is a high potential for confusion of input files among scenarios.

The most important aspect of the information provided for review of the three bounding scenarios is whether the changes in landscape configuration discussed under each scenario is accurately reflected in the WEPP hillslope input files. If the changes are not well described by the input files, the erosion and surface water modeling for each scenario will have little meaning. I have looked through many of the input files that were changed for each Scenario. It is difficult to tell from the input text file if the many changes correctly reflect the described scenarios.

I suggest that for Scenarios 1 and 2 the RFETS GIS personnel who have been assisting on the WEPP modeling project take a close look at the changes in landscape configuration for the proposed bounding scenarios. Overlay these on the existing hillslopes and check to be sure that the changes made in the WEPP input files are representative of the scenarios. If not, changes can easily be made to the input files before the final WEPP run and input of results to HEC-6T.

I have documented some changes I noted in the input files for the scenarios below. Comments on the WEPP input and output for each scenario are included in the following discussion.

Scenario 1 Comments

The runoff and sediment yield output looks reasonable and is in the range of previous modeling for the drainages. In Woman Creek, the results for hillslope 32 indicate that runoff is similar to the previous configuration but erosion per unit area has increased considerably, even thought the hillslope is much shorter. In general, it appears that when hillslopes were modified for length in Scenario 1 the slopes were not adjusted accordingly. This may account for the changes in output for hillslope 32.

Walnut Creek

Some of the changes noted in some slope files for scenario 1 for Walnut Creek are listed below. This is not a comprehensive list of changes but is representative of the types of changes made.
Hillslope 75 is 1 m shorter but the slope values have not changed.
Hillslope 74 is 4 m shorter but the slope values have not changed.
Hillslope 68 is 3 m shorter but the slope values have not changed.
Hillslope 67 is 34 m shorter but the slope values have not changed.
Hillslope 63 is 22 m shorter but the slope values have not changed.
Hillslope 55 is 2 m shorter but the slope values have not changed.
Hillslope 66 is 15 m shorter. The OFE 1 was shortened but the slope values have not changed.
Hillslope 46, OFEs 3 and 4 have been shortened, from the limited graphics available it appears that OFE 4 may disappear completely due to incorporation in the proposed wetland.

Woman Creek

The majority of Hillslope 32 appears to be in the new wetland area, east of Pond C-2, yet there are still three OFEs for the new hillslope, OFE 2 is much shorter but the slopes in the slope file are unchanged. It is unclear if the wetland is being modeled as part of the hillslope or as part of the drainage.

I don't believe my doing much more at this time is fruitful. The RFETS GIS personnel familiar with the approach used in the previous WEPP modeling should take a look at the hillslope changes to be sure they are consistent with previous approaches. For example, it appears that if area was lost on a hillslope it was shortened to compensate. In previous modeling the length of the hillslope was the flow length for runoff and the width was adjusted if necessary.

Scenario 2 Comments

I was not provided with a graphic for Walnut Creek that shows both the proposed retention structure and the WEPP hillslopes. Therefore, I cannot address the appropriateness of changes to hillslopes in the Walnut Creek drainage for Scenario 2. Generally the output looks to be reasonable compared to previous results.

In Woman Creek it appears that hillslopes 31, 32, 33, and 35 have been kept intact although in this scenario a dam or a drainage swale splits them. If I understand the graphics correctly, this configuration does not make hydrologic sense. If the hillslopes are indeed split by proposed features that will greatly influence surface drainage patterns they should be reconfigured to reflect the changes. New hillslope may need to be designated.

Again, I suggest that the RFETS GIS personnel familiar with the drainages and the approach used in the previous WEPP modeling should take a look at the hillslope changes to be sure they are consistent with the proposed landscape changes and previous approaches.

Scenario 3 Comments

Scenario 3 does show an overall decrease in sediment leaving the SID hillslopes, compared to the original model. However, the hillslope configurations do not appear to be consistent with the Scenario description.

Three main components are included in Scenario 3:

- Land re-contouring to provide positive drainage away from the IA VOC Plume.
- Grade reduction and drainage controls of the B881 / 903 Pad hillslope to improve slope stability and decrease soil erosion.
- Drainage improvement and controls to provide runoff diversion and channel stabilization.

A review of the WEPP input files indicates that the IA positive drainage has been incorporated. The grade reduction for the SID area has been incorporated, with grades generally reduced to between 9% and 11%. However drainage improvements and controls have not been incorporated into the WEPP model for the SID.

Four components to the reconfiguration scenario for the SID area are mentioned in the *Draft Appendix C, Scenario Development and Evaluation for Land Configuration Design Basis Project*. These include:

- **Grade Reduction**

The grade reduction appears to have been incorporated into the current WEPP model.

- **Toe Buttress and Subsurface Drain**

It is not clear from the description in Appendix C if the toe buttress will have an impact on the hillslope profile. If it does, the impact should be incorporated into the current model. Currently, it does not appear that it is.

- **Hillslope Contouring, Terracing, and Drainage**

The current model has little evidence of terracing. In the current model the areas of reduced slopes are in areas with existing roads and are quite similar to the original AME model. It is not clear that terracing has been incorporated into the model as an intentional and engineered response to control erosion. There is no evidence of the drainage channels mentioned in Appendix C.

- **Re-vegetation**

None of the roads have been re-vegetated in this WEPP scenario. In fact the road that runs along the North side of the SID on hillslopes 18, 19, and 20 has been converted from an unimproved road with partial vegetation to an improved road with no vegetation. All roads, except for hillslope 11 and part of hillslope 12, appear to be unaffected by this scenario. I suggest they all be removed unless there is a pressing need for them after closure.

The current WEPP model for Scenario 3 may show the effect of slope reduction on the SID. Sediment loads are reduced for the 100-year storm. The reviewer did not determine if this reduction may be partially due to model artifacts. However, it must be recognized and will be explicitly stated in the report on the WEPP and HEC-6T modeling that the model does not address the potential effects of hillslope drainage controls or re-vegetation. These are two very important components of Scenario 3. Their potential effects on runoff and erosion may be greater than slope reduction alone. The reviewer does not understand how this scenario can be adequately evaluated if these components are not included in the modeling. The WEPP and HEC-6T modeling to be done for Scenario 3 will not evaluate the Scenario as presented in Appendix C.

The IA slope input files for Scenario 3 indicate some very large changes from Scenario 0 in hillslope configurations including width, length and area. These changes are not are not shown in the figures provided by Parsons. The OFE outlines shown for the IA in the latest graphics (Labeled Scenario 3) are the same as for Scenario 0. Perhaps the changes had not been incorporated as of the transmittal date. It is very important that all changes between Scenarios be documented and clearly indicated in any graphics of the hillslopes. The following are a few examples of changes not shown on the scenario 3 GIS maps for the IA.

Hillslope 228 is new and is not on the OFE map for Scenario 3 provided by Parsons.
Hillslope 121 shortened significantly. Slope has changed slightly.
Hillslope 86 is narrower, longer, and has larger area. Slopes generally steeper.
Hillslope 88 is longer and narrower.
Hillslope 141 is wider and shorter with slightly steeper slopes.
Hillslope 218 is narrower and longer with steeper slopes.
Hillslope 225 has become narrower and longer with a larger area.
Hillslope 225 is more than twice as wide and less than a third as long.

Any graphics showing the hillslopes for this scenario should show these changes. They are significant.

Meeting Minutes

Date: August 28, 2001
Location: RFETS, T130-C North Conference Room
Attendees: Greg Wetherbee
Win Chromec (intermittent teleconference)
Bruce Curtis
Georgia Vondra
Paul Frink

Subject: Outstanding Modeling Issues for LCDB Scenarios

Purpose: Review open concerns regarding the modeling efforts to date for Scenarios 0, 1, 2, & 3 of the LCDB Project. Discuss the path forward for completion of those activities. The overall objective is to gain concurrence that, all outstanding issues with regard to modeling activities for Scenarios 0, 1, 2 & 3 will be adequately resolved.

Process: Issues, concerns and suggestions for each scenario were covered in separate discussions and are listed here. General items are included at the end of the minutes. Each issue/concern is listed along with the resolution accepted by the group. Action items, responsibilities and proposed completion dates are also listed.

Scenario 0 (conditions at end of active remediation)

Issue #1 – **Significant changes to WEPP input files**. During modeling of Scenario 0, a significant number of changes were made to the WEPP input files for the SID hillslopes. The extent of these changes may have invalidated the calibration activities that were previously performed by AME. Parsons has performed a sequential analysis of the changes that were made using SID Hillslope 10 to determine the impact of each change and to verify that changes are not an artifact of the WEPP Model.

Resolution: After reviewing the preliminary results it was determined that the changes appeared to be logical, reasonable and defendable. Win Chromec asked that the analysis be formalized for his review and documented in the final report.

Action: Parsons will document this analysis in the modeling approach section of Appendix E to the CDR " Erosion and Actinide Evaluation Report" and forward a draft to Mr. Chromec. Due: September 7, 2001.

Issue #2 – **Appearance of Erosion Map**. It was previously identified that when modeled erosion rates for the IA for Scenario 0 were plotted spatially on a site map, the results provided erosion rates that were not consistent for adjacent hillslopes at two locations. . Hence, Parsons adjusted the input parameters for these hillslopes to generate a smoother output that would make the erosion rates more consistent across the IA.

Resolution: After reviewing the new erosion map plotted as a result of these changes, there was concurrence that this action had been effective.

Action: No additional action.

Issue #3 – Generation of IA Hillslopes. No data exists to calibrate the OFEs and hillslopes generated by Parsons for the Industrial Area. Those files were verified by comparing the generated results to similar OFEs previously modeled and calibrated in the Buffer Zone.

Resolution: It was agreed that the approach and results were reasonable and acceptable.

Action: No additional action

Issue #4 – Modeling approach for the present landfill. The present landfill is currently modeled as a single hillslope containing three OFEs (Topslope, road, and Sideslope). There was a concern that, although the approach is reasonable from a modeling point of view, it may appear illogical to a casual reviewer. There are several other ways this area might be modeled, but they would likely involve considerably more effort and would not improve modeling results.

Resolution: After discussion it was agreed that the current approach was acceptable and defendable due to the lack of any significant actinide concentration in the landfill cover.

Action: Parsons will explain this approach in the modeling approach section of Appendix E. Due with final scenario model package.

Scenario 1 (Flow-through Ponds and Wetlands)

Issue #5 – Changes to Walnut and Woman Creek Hillslopes. It appears that Parsons has shortened the previous lengths of OFEs in the Walnut and Woman Creek basins without changing the slopes. The purpose was not understood.
When wetlands were modeled in this scenario the drainage channel was widened. The wetland themselves will be modeled in HEC-6T. Therefore the OFEs adjacent to the channels were shortened to accommodate the wetland areas. The slope changes were not significant and were therefore not adjusted.

Resolution: After discussion it was agreed that this approach was logical and acceptable. However, it needs to be documented in the modeling approach.

Action: Parsons will document this approach in the modeling approach section of Appendix E. Parsons will also confirm that all transects snap to an OFE boundary.

Issue #6- OFE #4 in hillslope 46 should be deleted due to its incorporation as a wetland area.

Resolution: Walnut Creek Hillslope 46 OFE # 4 should have been deleted and was an oversight on Parsons part.

Action: Parsons will delete the OFE. Due with final scenario model package.

Scenario 2 (Detention Basins)

Issue #7 - Splitting hillslopes. It was not clear whether hillslopes that were effected by the proposed Woman Creek Detention Basin embankment or dam were split.

Resolution: On Woman Creek, hillslopes were split for both the embankment and dam. On Walnut Creek, because of the location of the dam there was on a small amount of area affected and the hillslopes were not split. It was agreed that this was acceptable.

Action: Parsons will explain this approach in the modeling approach section of Appendix E.

Issue #8 - Files. There was some confusion whether GIS data files contained transects that were reflective of the split hillslopes and if they did were these transects snapped to OFE boundaries.

Resolution: Provided coverages do have transects included and the transects were snapped appropriately.

Action: AME will check with site GIS to perform QA on the coverages provided by Parsons to verify the above. AME will notify Parsons if there are any concerns.

Scenario 3 (Source Isolation, Drainage Diversion, and Erosion Controls)

Issue #9 - Scenario features not modeled. Parsons has not modeled all the features (components) described in the Scenario 3 description as some were included in the write-up as contingencies. This was not clearly stated in the write-up. It is felt that the description and the modeling effort need to be consistent. Missing features included toe buttress at base of 903 Pad hillside, terracing of 903 pad hillside, and removal of roads.

Resolution: It is agreed that the model activities must be consistent with the write-up. Either need to model the features or explain in the text why a given component is a contingency or will be considered/addressed later. Specifically:

1. Toe Buttress, This feature has no effect on the model so there nothing to model.
2. Terracing of 903 Pad, It was agreed that this would have a strong potential to cause significant changes in the erosion results and modeling should be evaluated if it is kept as part of the scenario description.
3. Removal of roads, although some roads will be removed, this aspect will be determined by the sector reconfiguration strategy for the ICD and is thus not a specific feature of this scenario.

Action: Parsons will model the terracing and will revise scenario description text to explain road removal. The Toe Buttress will be explained in the modeling approach section of Appendix E. Due with final scenario model package.

Issue #10 - Too much detail in Scenario 3. The Scenario 3 write-up included significantly more technical detail than the other two scenarios. Much of the technical information was not needed at this level.

Resolution: Remove unnecessary technical information.

Action: Parsons will revise the Scenario description. Due with final scenario model package.

Issue #11 - Culvert Removal. Description of culvert removal and areas where engineered channels will be constructed is not clear.

Resolution: Need to explain details better (specifically which ones are removed by Scenario 0 and Scenario 3 and where engineered channels are constructed). Also need to provide channel information to AME.

Action: Parsons will explain culvert removal more explicitly in the modeling approach section of Appendix E. Additionally, Parsons will revise the description of anticipated condition at completion of active remediation (scenario 0) in the design basis to identify culvert status. Due with final scenario model package. Parsons will provide HEC-GeoRAS cross-sections of the open channels to AME. Due 8/30/01

General

Issue #12 – GIS <u>Scenario coverages are not complete</u>. Complete GIS coverages were not issued for each scenario.

Resolution: Only the changed or effected GIS coverages for each scenario have been issued to date, however, it would be beneficial and improve documentation if a complete GIS coverage was issued/archived for each scenario

Action: Parsons will determine if complete GIS coverages of all hillslopes for each scenario can be transmitted. If possible Parsons will transmit entire coverage for each scenario. Due with final scenario model package.

Issue #13 - <u>File Identification</u>. Similar files for OFEs/Hillslopes have been assigned the same name across all scenarios. Although the files should always be segregated in folders by scenario, this could possibly lead to confusion.

Resolution: Agreed, assigning scenario specific file names and adding text to the files to identify which scenario the files belongs to would improve documentation and quality assurance for the project.

Action: Parsons will make appropriate changes to the files so they can be readily identified by scenario. Due with final scenario model package.

APPENDIX B

Actinide Mobility Maps for Scenarios 1 and 3

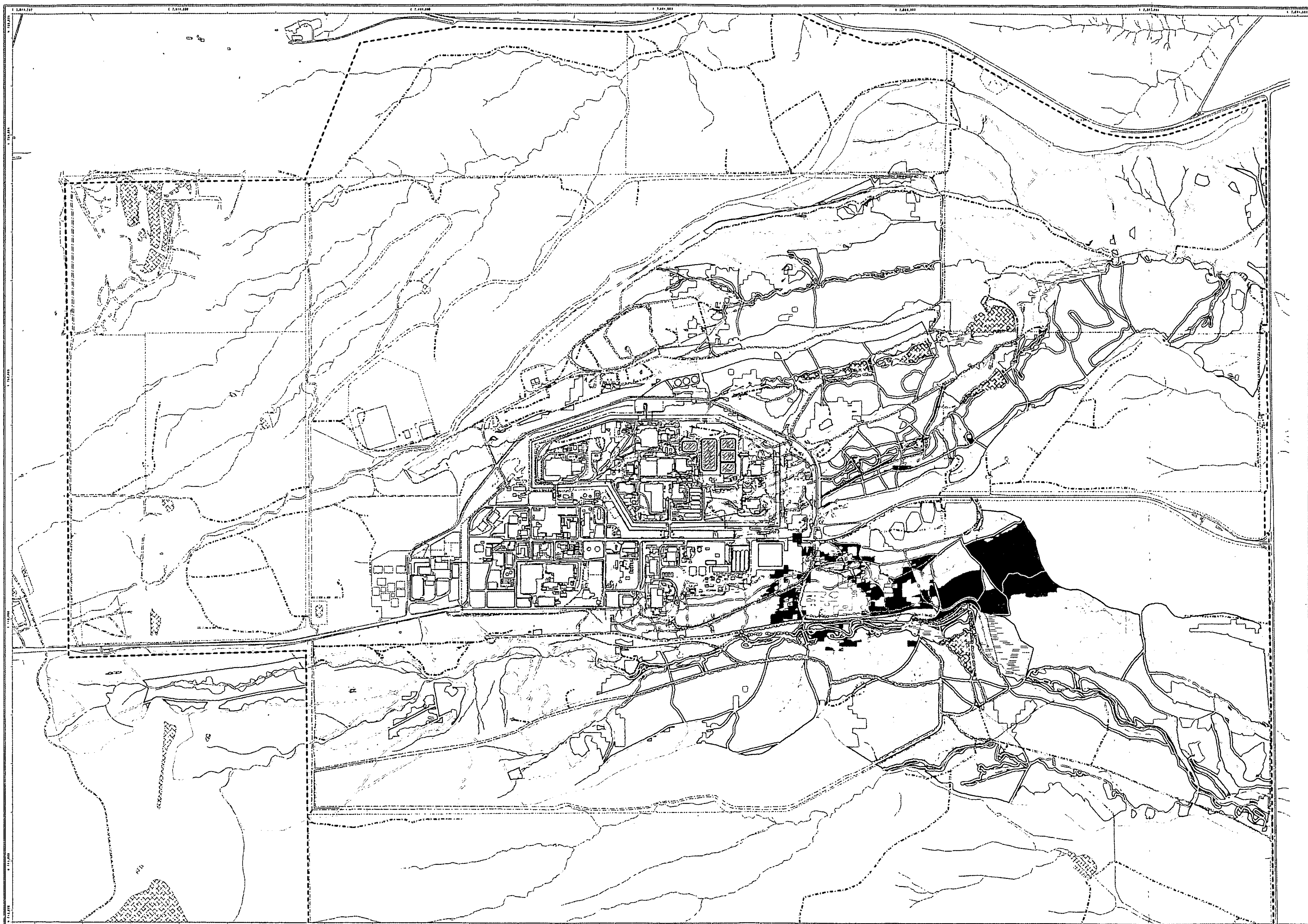


Figure B-1
LCDB Scenarios 0, 1 and 2
Pu-239,240 Mobility
100-Year Event (97.1mm)

EXPLANATION

Low

Relative Actinide

Mobility Scale

High

Area not modeled

Wetland

Standard Map Features

Solar Evaporation Ponds (SEPs)

Lakes and ponds

Streams, ditches, or other drainage features

Fences and other barriers

Rocky Flats boundary

Paved roads

Dirt roads

DATA SOURCE BASE FEATURES:

Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95

Scale = 1 : 18350
1 inch represents approximately 1813 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy

Rocky Flats Environmental Technology Site

GIS Dept. 303-966-7707

MAP ID: 02-0156/all_pu_mob_m2_scn1.aml

December 27, 2001

Figure B-2
LCDB Scenarios 0, 1 and 2
Am-241 Mobility
100-Year Event (97.1mm)

EXPLANATION

- Low
- Relative Actinide
- Mobility Scale
- High
- Area not modeled
- Wetland

Standard Map Features

- Solar Evaporation Ponds (SEPs)
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Rocky Flats boundary
- Paved roads
- Dirt roads

DATA SOURCE BASE FEATURES:

Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95

Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95

Scale = 1 : 19350
1 inch represents approximately 1613 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy
Rocky Flats Environmental Technology Site

GIS Dept. 303-966-7707

MAP ID: 02-0156/all_am_mob_m2_scn1.aml December 27, 2001

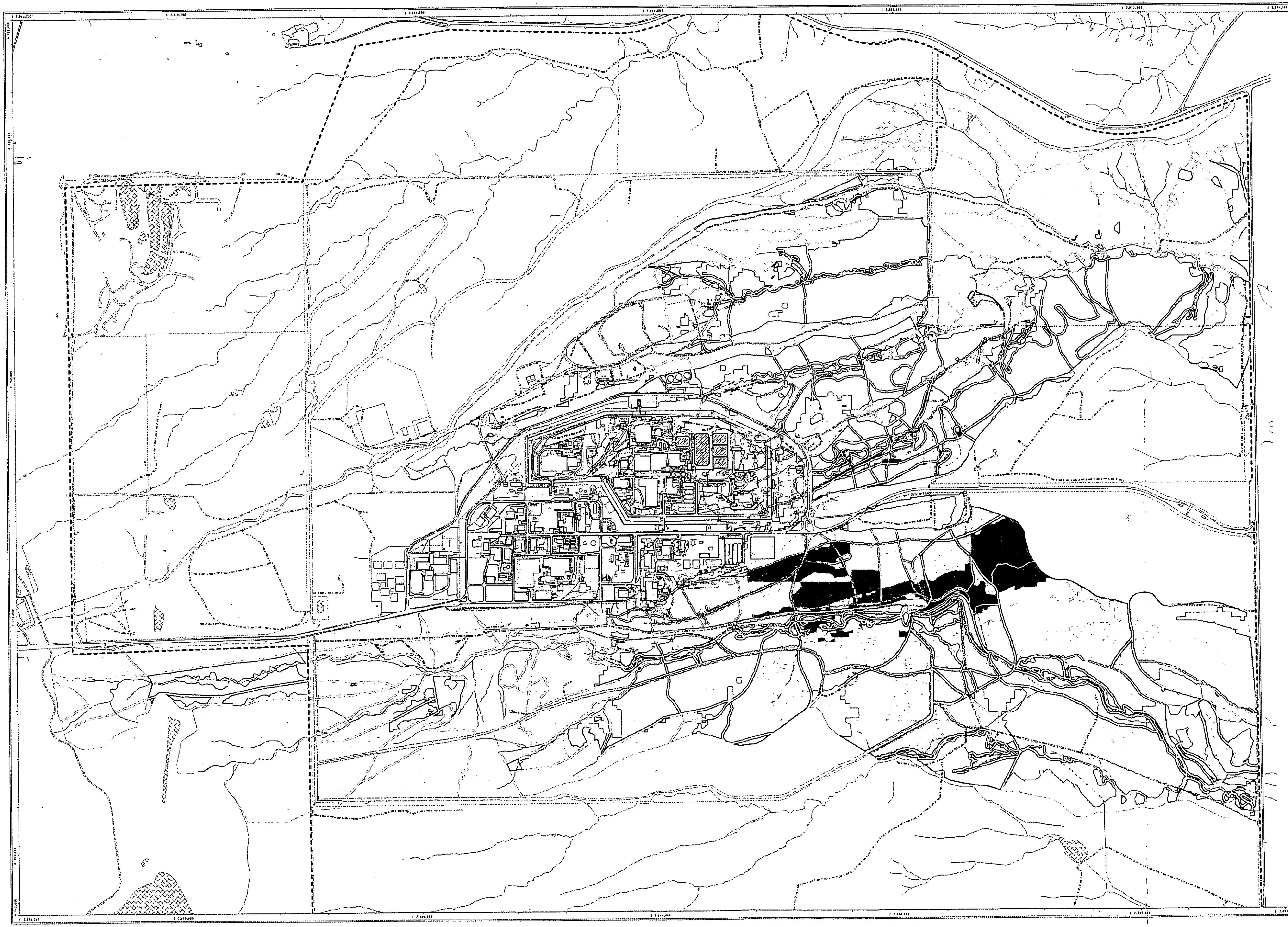


Figure B-3
LCDB Scenario 3
Pu-239,240 Mobility
100-Year Event (97.1mm)

EXPLANATION

- Low
- Relative Actinide
- Mobility Scale
- High
- Area not modeled
- Wetland

Standard Map Features

- Solar Evaporation Ponds (SEPs)
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Rocky Flats boundary
- Paved roads
- Dirt roads

DATA SOURCE BASE FEATURES:

Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95

Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95

Scale = 1 : 18350
1 inch represents approximately 1513 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy

Rocky Flats Environmental Technology Site

GIS Dept. 303-966-7707

MAP ID: 02-0159/all_pu_mob_m2_scn3.aml

December 26, 2001

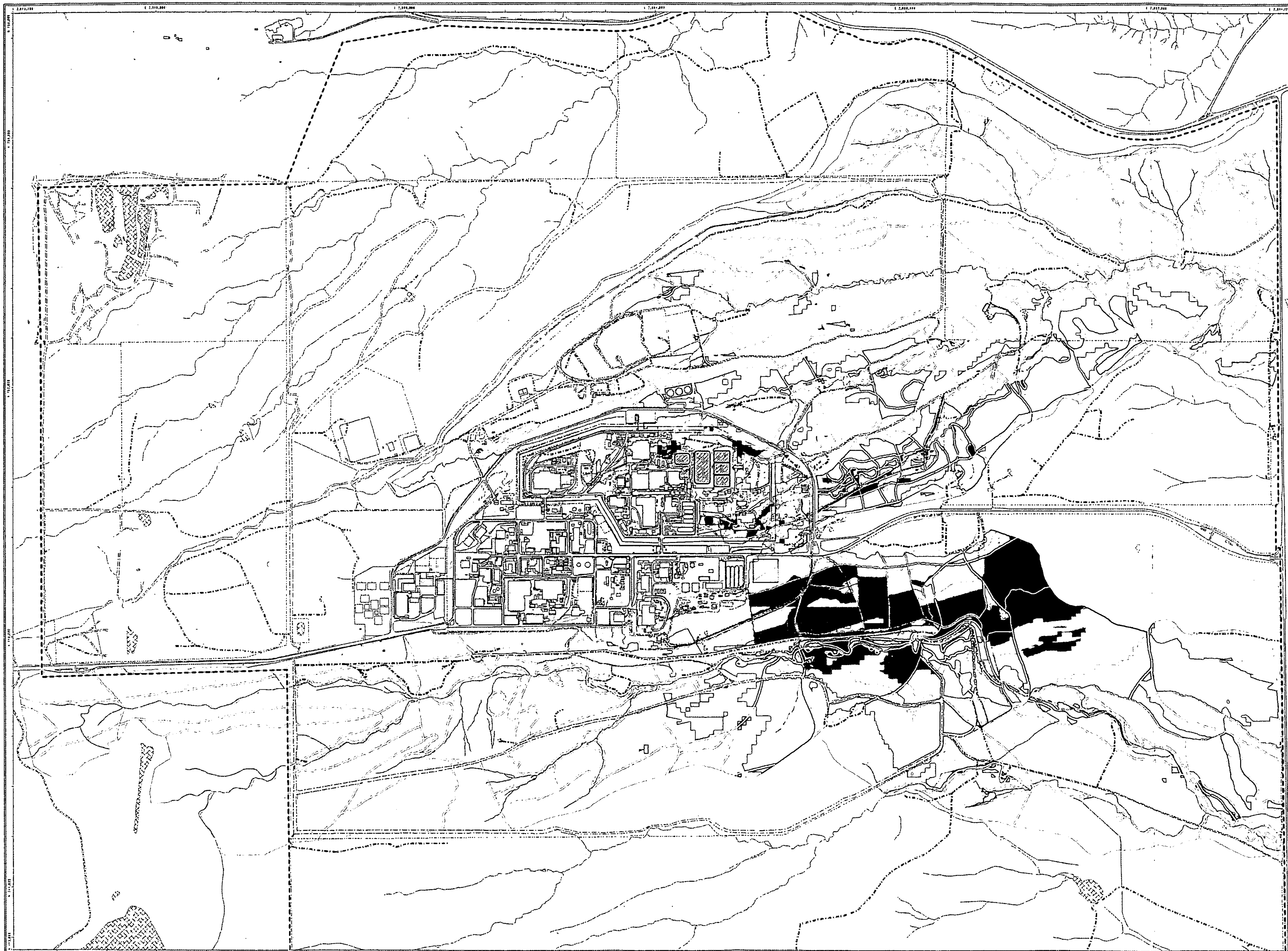


Figure B-4
LCDB Scenario 3
Am-241 Mobility
100-Year Event (97.1mm)

EXPLANATION

- Low
- Relative Actinide
- Mobility Scale
- High
- Area not modeled
- Wetland

Standard Map Features

- Solar Evaporation Ponds (SEPs)
- Lakes and ponds
- Streams, ditches, or other drainage features
- Fences and other barriers
- Rocky Flats boundary
- Paved roads
- Dirt roads

DATA SOURCE BASE FEATURES:

Buildings, fences, hydrography, roads and other structures from 1994 aerial fly-over data captured by EG&G RSL, Las Vegas. Digitized from the orthophotographs. 1/95

Scale = 1 : 10350
1 inch represents approximately 1013 feet

State Plane Coordinate Projection
Colorado Central Zone
Datum: NAD27

U.S. Department of Energy

Rocky Flats Environmental Technology Site

GIS Dept. 303-966-7707

MAP ID: 02-0150/all_am_mob_m2_scn3.aml

December 20, 2001

APPENDIX C

Modeling Data CD-ROM